

COMMERCIAL BUILDING ENERGY CODE TRAINING

Building Codes Assistance Project



Course Overview

- Introduction to Energy Codes
 - The Value of Energy Codes
 - National and Regional perspectives
- 2009 IECC/Standard 90.1-2007 Commercial Energy Codes
 - Interrelationship – IECC and ASHRAE 90.1-2007
 - Envelope Prescriptive Approach
 - Lighting and HVAC overview
 - COMcheck Software
 - Green and Advanced Codes

Best Practices

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BCAP

Dedicated to the adoption, implementation,
and advancement of building energy codes

Learning Objectives

1. *Put energy codes in their economic context by identifying the financial benefits of energy code adoption.*
2. *Name two significant environmental benefits achieved through energy efficiency gains in the building sector.*
3. *Apply knowledge of energy code costs to dispel myths about the high price of energy codes to building owners, developers and tenants.*
4. *Identify five energy code requirements that are universal to each climate zone along with the energy code design variations by climate zone.*

Learning Objectives

5. *Explain how the standard requirements of the energy code and variations by climate zone influence the plan review and site inspection process.*
6. *Identify the three compliance pathways for commercial buildings outlined in the code and when to apply them.*
7. *Identify each of the three compliance pathways for commercial buildings outlined in the energy code and when to apply them.*
8. *Explain the differences between each of the compliance pathways and how they relate to overall building design.*

Learning Objectives

- 9. *Explain the intent behind air sealing and how it improves energy efficiency in commercial buildings.*
- 10. *Explain the intent of duct insulation, placement, and appropriate duct design for increased energy efficiency in residential and commercial buildings.*
- 11. *Explain the role of envelope insulation and correct material identification and how it relates to increased energy efficiency in both residential and commercial buildings.*
- 12. *Identify the principles of air movement through the building envelope and how energy code requirements help prevent unintended air movement.*

Learning Objectives

- 13. *Navigate the COMcheck software to determine compliance with Standard 90.1-2007 and Chapter 5 of the 2009 IECC.*
- 14. *Explain how the energy code effects design decisions for different building types.*
- 15. *Explain how code provisions relate to new construction versus remodels and renovations.*

Impact of Buildings

- ~40% of total energy use in the US
- 70% of total US electricity consumption
- 40% of CO₂ emissions – on average.....

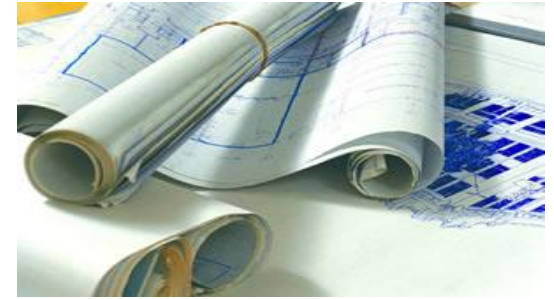
The average home emits twice as much GHG as the average car

In 2004, 2+ million housing units permitted in US (NAHB)



VALUE of Energy Codes

Affects ALL new buildings



By 2020:

- **23.4 million** new housing units
- Over **1 trillion** sq feet commercial floor space

By 2030:

- Over **41 million** new housing units
- Over **2 trillion** sq feet commercial floor space

Source: EIA, Annual Energy Outlook 2008

VALUE of Energy Codes

Establish a foundation for *advanced energy* efficiency and *green* programs:

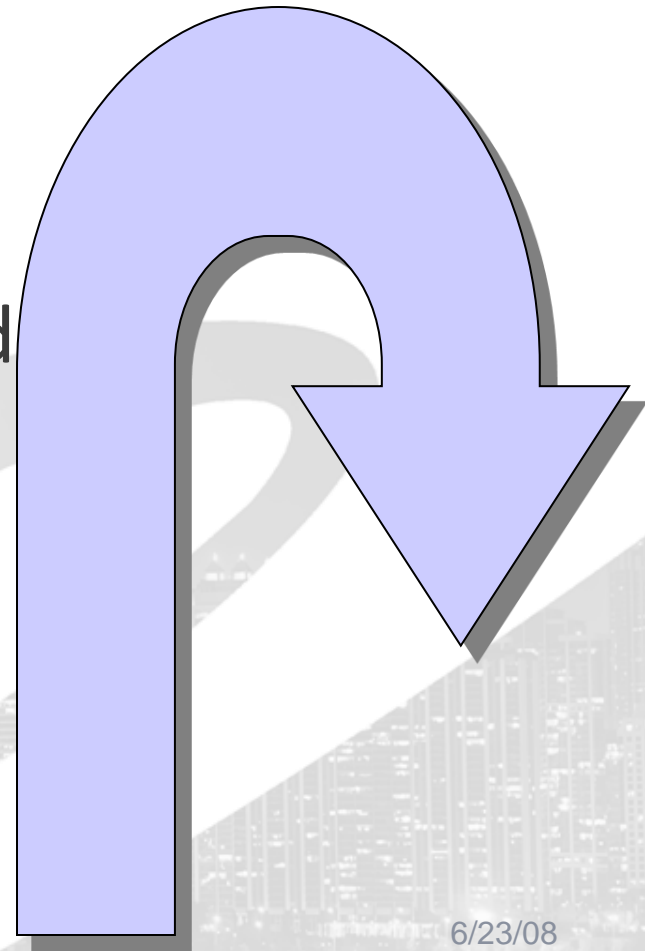
- ENERGY STAR,
- LEED homes and commercial buildings,
- ASHRAE Standard 189
- ICC IgCC and ICC-700
- Building America/ federal tax incentive, and
- Net-zero energy buildings



Also...

High performance buildings,
advanced standards, and green
building initiatives

prepare the market so that
the construction sector can handle
increased energy
efficient requirements
through codes



Buildings are critical in addressing energy and climate

Efficient buildings

1. Reduce stress on electric grid and natural gas supplies
2. Improve air quality and public health
3. Avoid global climate change
4. Save consumers money
5. Reduce foreign oil dependency

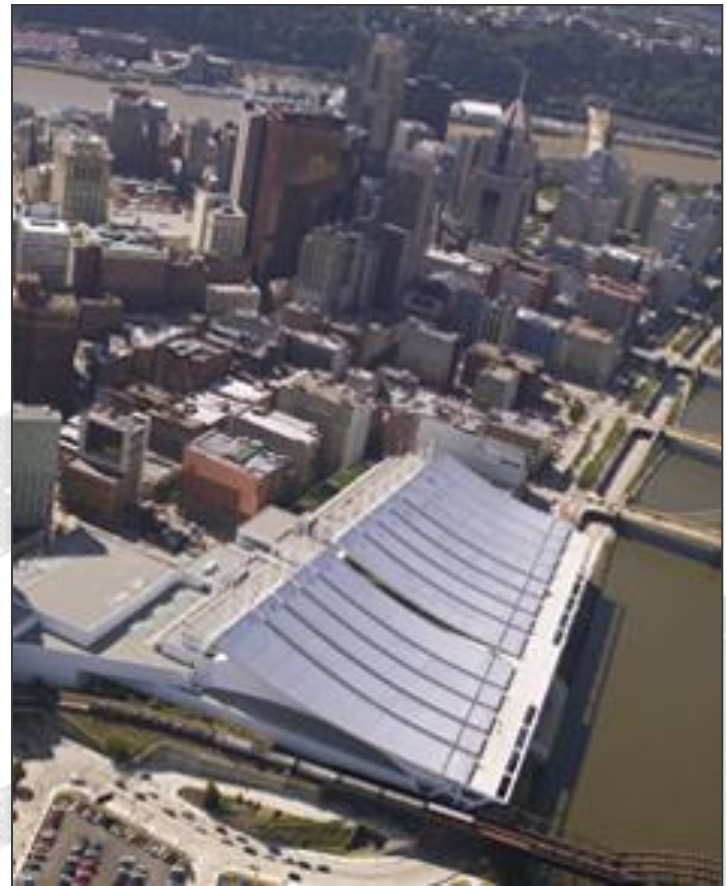


Energy Consumption in Commercial Buildings

More than half of energy use is for HVAC and lighting

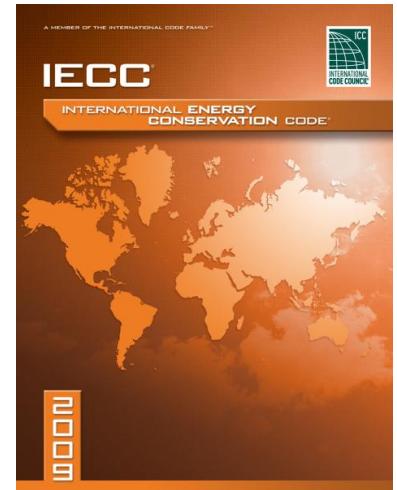
Off-the-shelf technologies can cut energy bills by 50%

Energy bills equals 25% of total operating costs

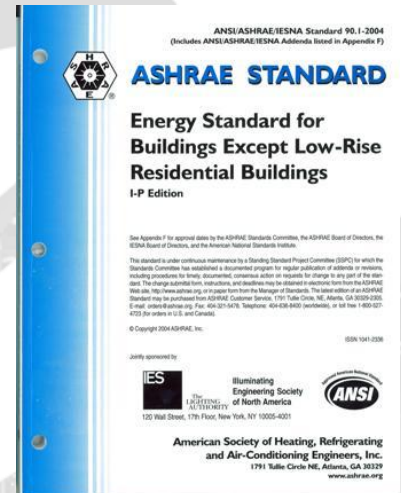


Commercial Building Compliance – IECC and Standard 90.1

IECC
Chapter 5 can be used to demonstrate compliance



ASHRAE
Chapter 5 of the IECC references ASHRAE 90.1-2007 as an option to demonstrate compliance



Compliance Options?

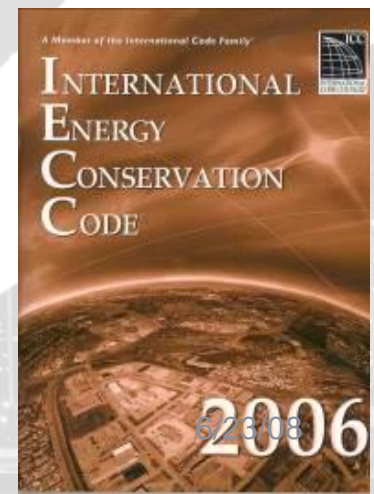
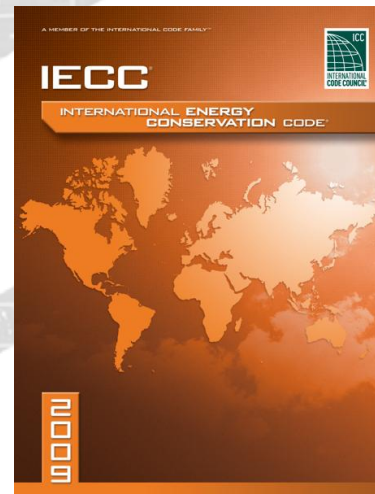


- Chapter 5 of the IECC General Prescriptive Approach
 - Use for buildings with $\leq 40\%$ of gross wall area in vertical fenestration
 - Use for buildings with $\leq 3\%$ of gross roof area in skylights
- Section 506 Total Building Performance Approach
- ASHRAE/IESNA Standard 90.1-2007
 1. Section 501.2 “Application” requires 90.1 to be used in its entirety (Envelope, Lighting, Mechanical) if used as an alternate compliance path
- COMcheck – Usable for IECC or ASHRAE, more later

Structure of the IECC

- Chapter 1 Administrative
- Chapter 2 Definitions
- Chapter 3 Climate Zones
- Chapter 4 Residential Energy Efficiency
- Chapter 5 Commercial Energy Efficiency
- Chapter 6 Referenced Standards

And... ASHRAE 90.1 and the relationship for compliance



Structure of Standard 90.1

Section 1 – Purpose

Section 2 – Scope

Section 3 – Definitions, Abbreviations and Acronyms

Section 4 – Administration and Enforcement

Section 5 – Building Envelope

Section 6 – HVAC

Section 7 – Service Water Heating

Section 8 – Power

Section 9 – Lighting

Section 10 – Other Equipment

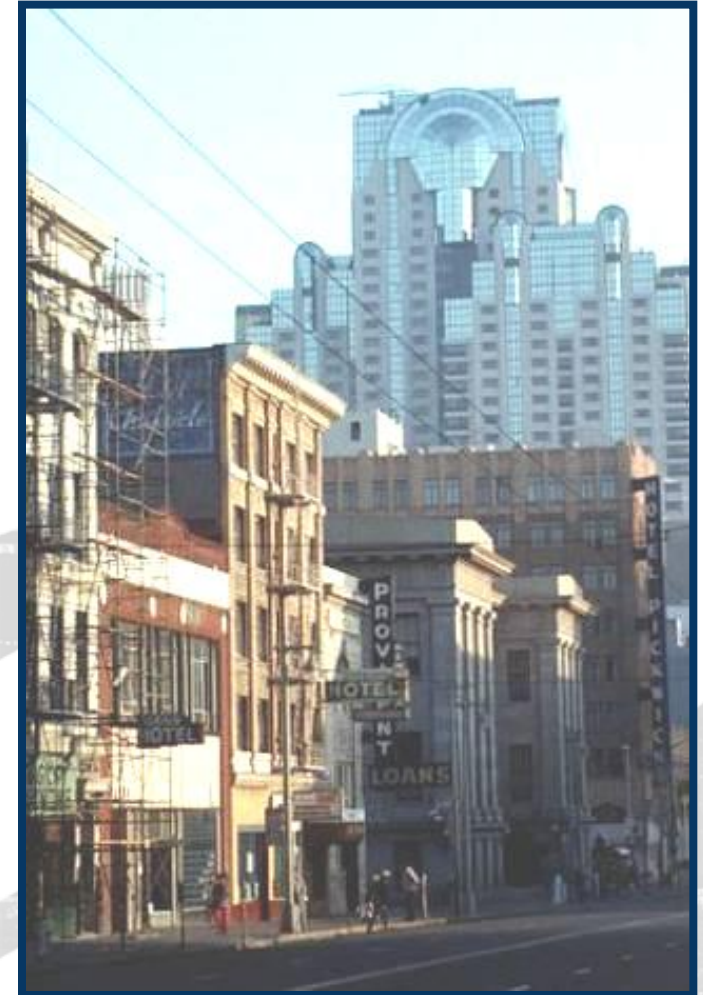
Section 11 – Energy Cost Budget Method

Section 12 – Normative References

What Projects Must Comply?

Standard 90.1-2007

- New buildings and their systems
- New *portions* of buildings and their systems (additions)
- New systems and equipment in *existing* buildings (alterations)



What Projects Must Comply? 2009 IECC

All buildings that are not
“residential” by definition are
“commercial”



Residential Buildings:

Single-family, duplex, and townhouses

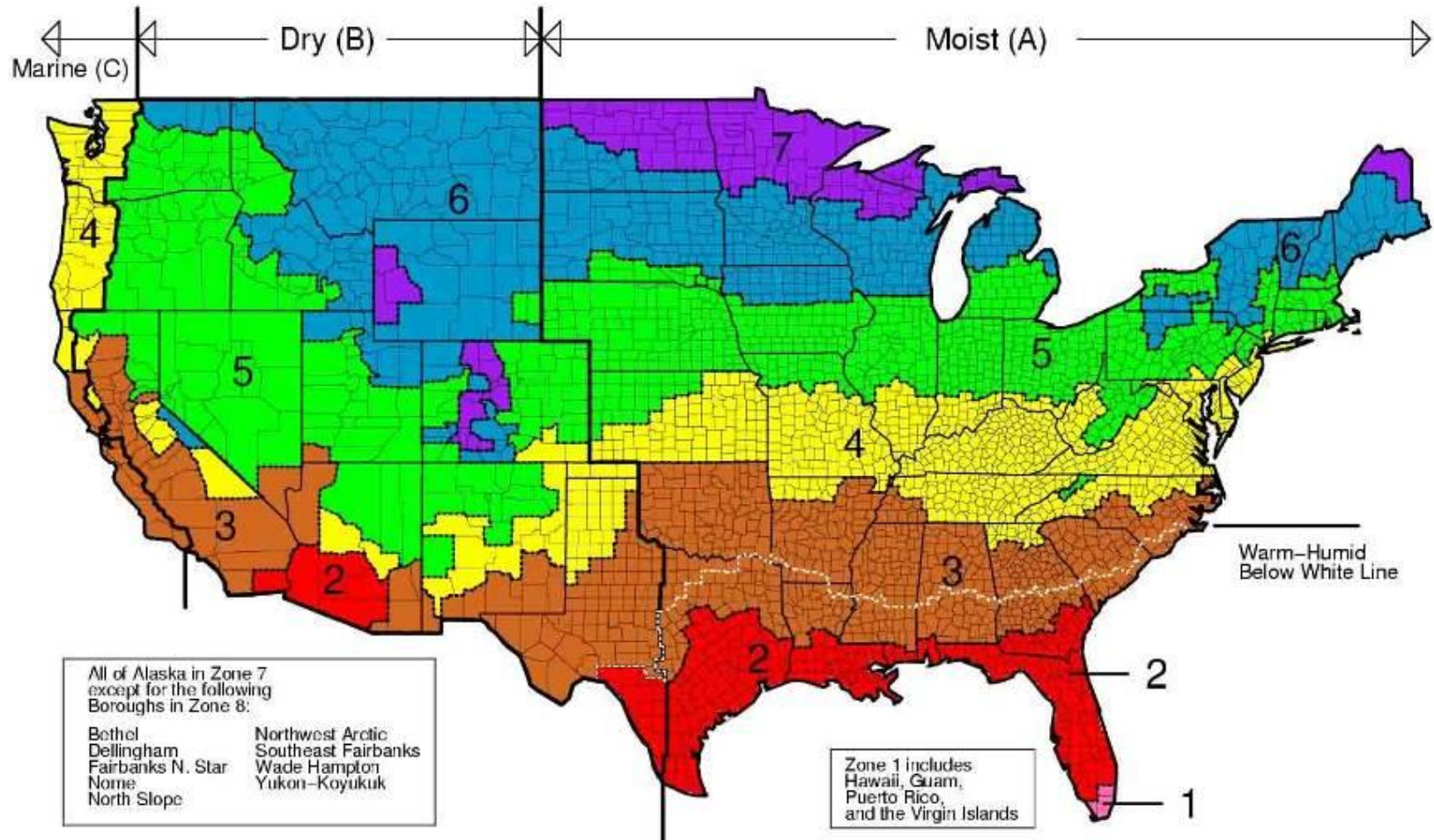
All low-rise (1-3 stories) houses, condos,
and apartments [R-2, R-3, R-4], but not
hotels/motels [R-1]



Additions, Alterations, Renovations, Repairs (IECC)

- Conform as relates to new construction
- Unaltered portion(s) do not need to comply
- Additions can comply alone or in combination with existing building
- Exceptions
 1. Storm windows over existing fenestration
 2. Glass only replacements
 3. Exposed, existing ceiling, wall or floor cavities if already filled with insulation
 4. Where existing roof, wall or floor cavity isn't exposed
 5. Reroofing for roofs where neither sheathing nor insulation exposed
 - Insulate above or below the sheathing
 - Roofs without insulation in the cavity
 - Sheathing or insulation is exposed

Climate Zones- Both Standard 90.1 and IECC



Determining Your Climate Zone is the First Step in the Process

Mandatory Energy Code Requirements: Standard 90.1/IECC

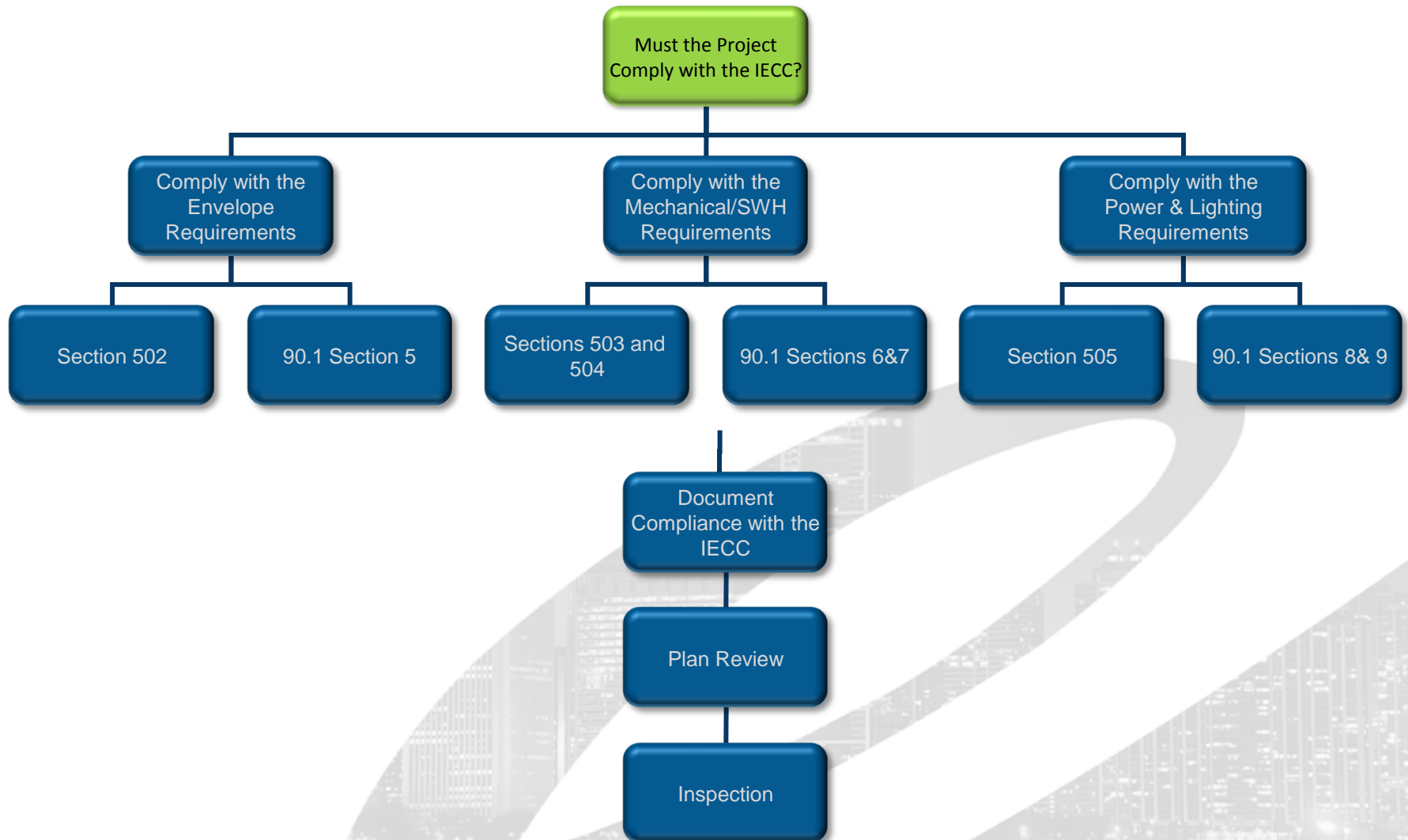
Basic requirements (apply everywhere):

- Duct insulation and sealing
- Infiltration control
- Temperature controls
- Pipe insulation
- Lighting
- *Mechanical*
- *Service Water Heating*

Climate Specific Requirements:

- *Envelope*

Commercial Code Compliance IECC



Compliance Approaches - Standard 90.1

Building System

Envelope

HVAC

SWH

Power

Lighting

Other

Mandatory Provisions

(required for most compliance options)

Compliance Options

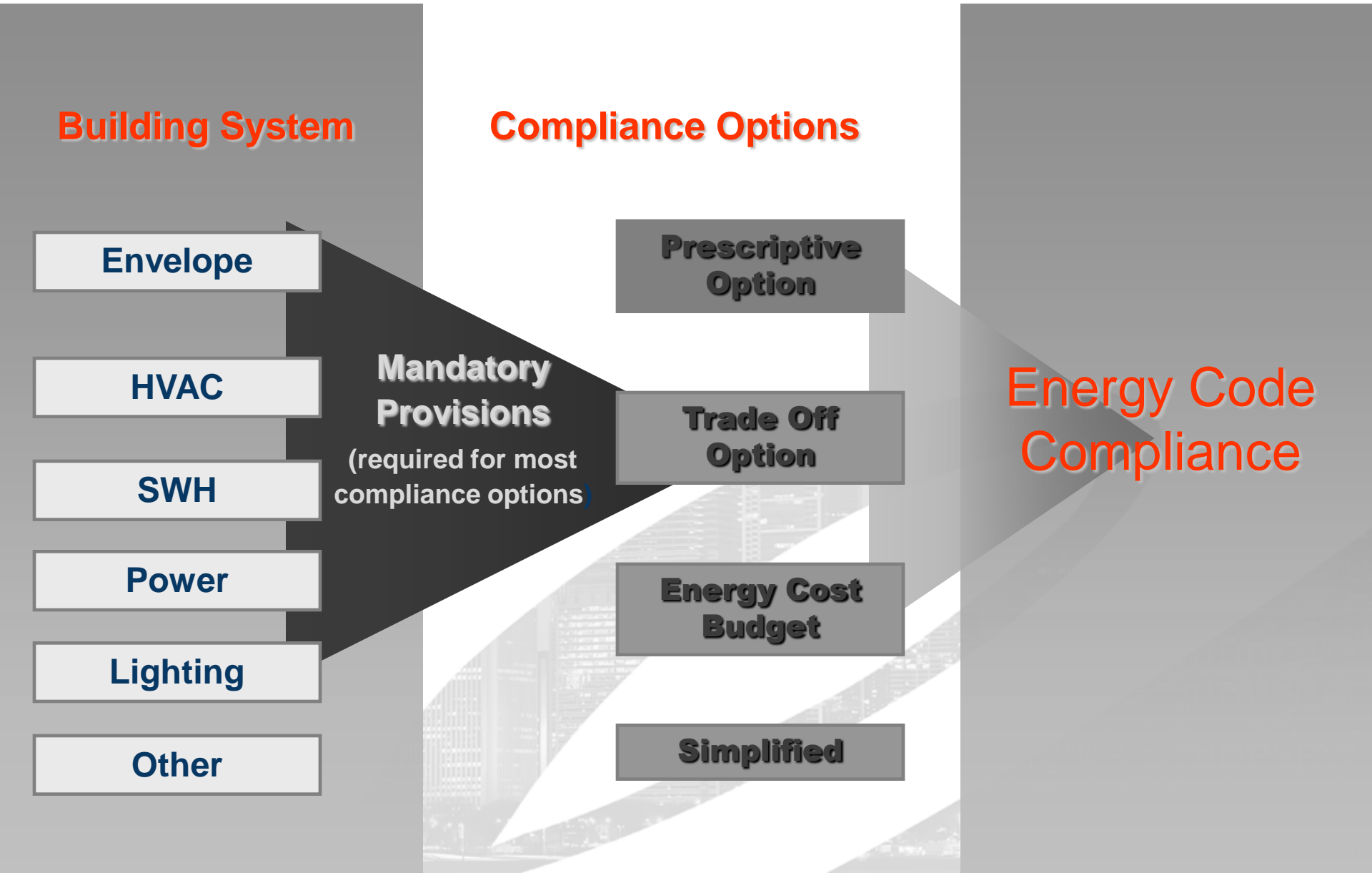
Prescriptive Option

Trade Off Option

Energy Cost Budget

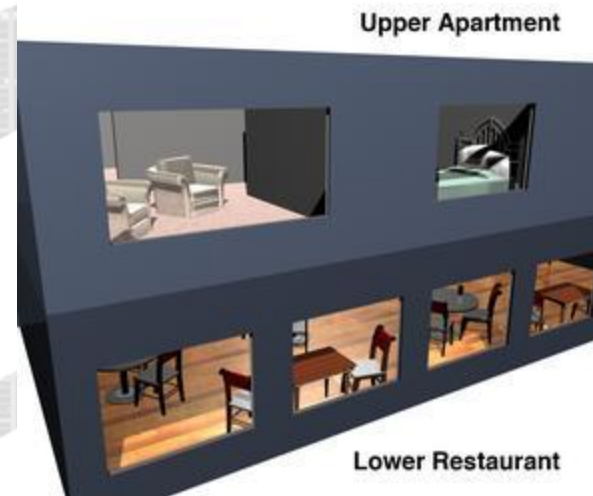
Simplified

Energy Code Compliance



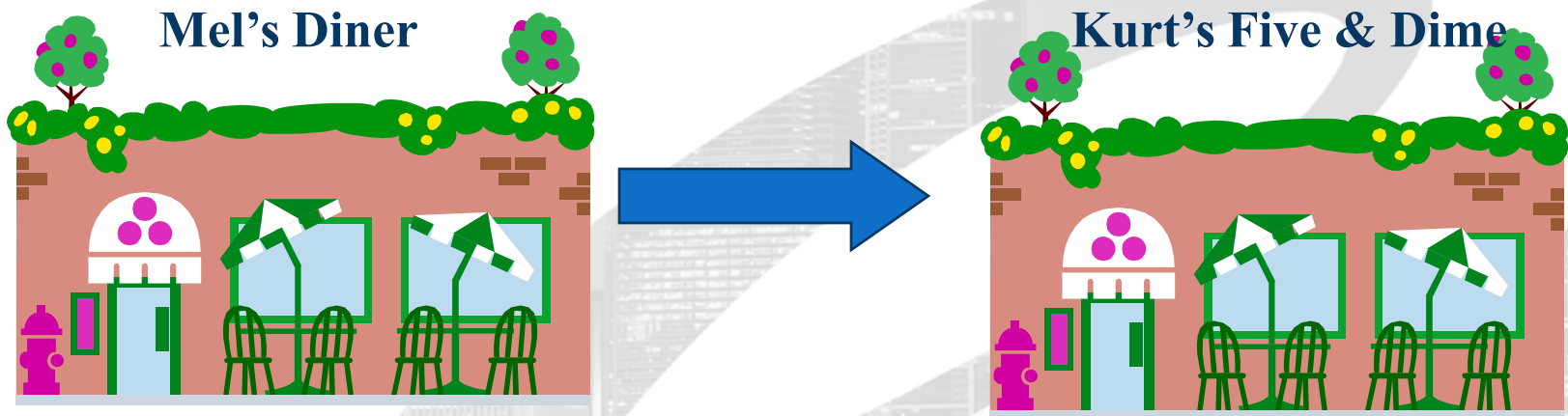
Mixed Use Buildings

- Mixed occupancies
 1. Treat the residential occupancy under the applicable residential code
 2. Treat the commercial occupancy under the commercial code



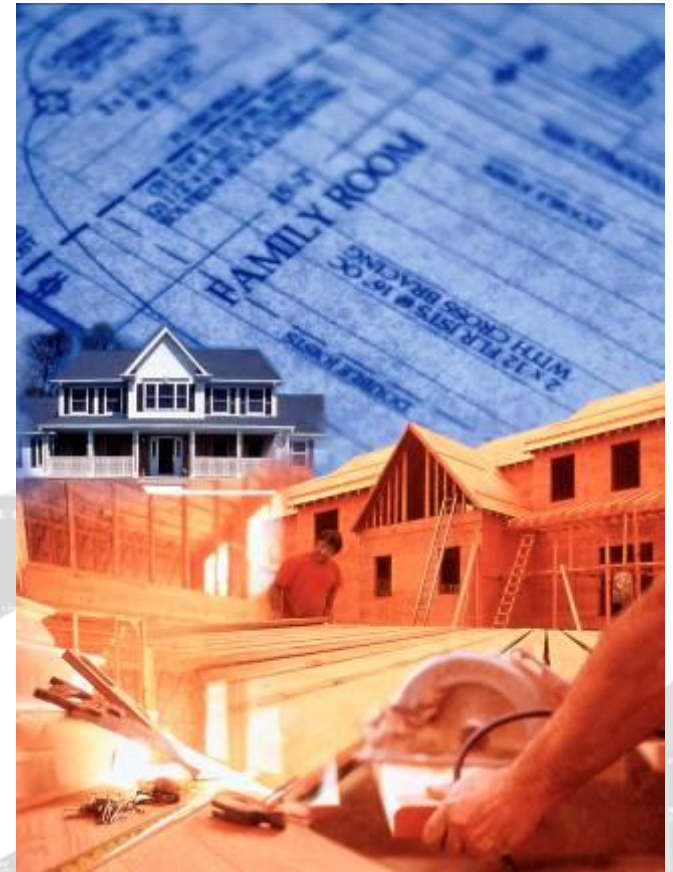
Change in Occupancy

- No action is required if alterations are not made to the building systems OR ...
if not going from unconditioned to conditioned



Compliance/Documentation/Inspections

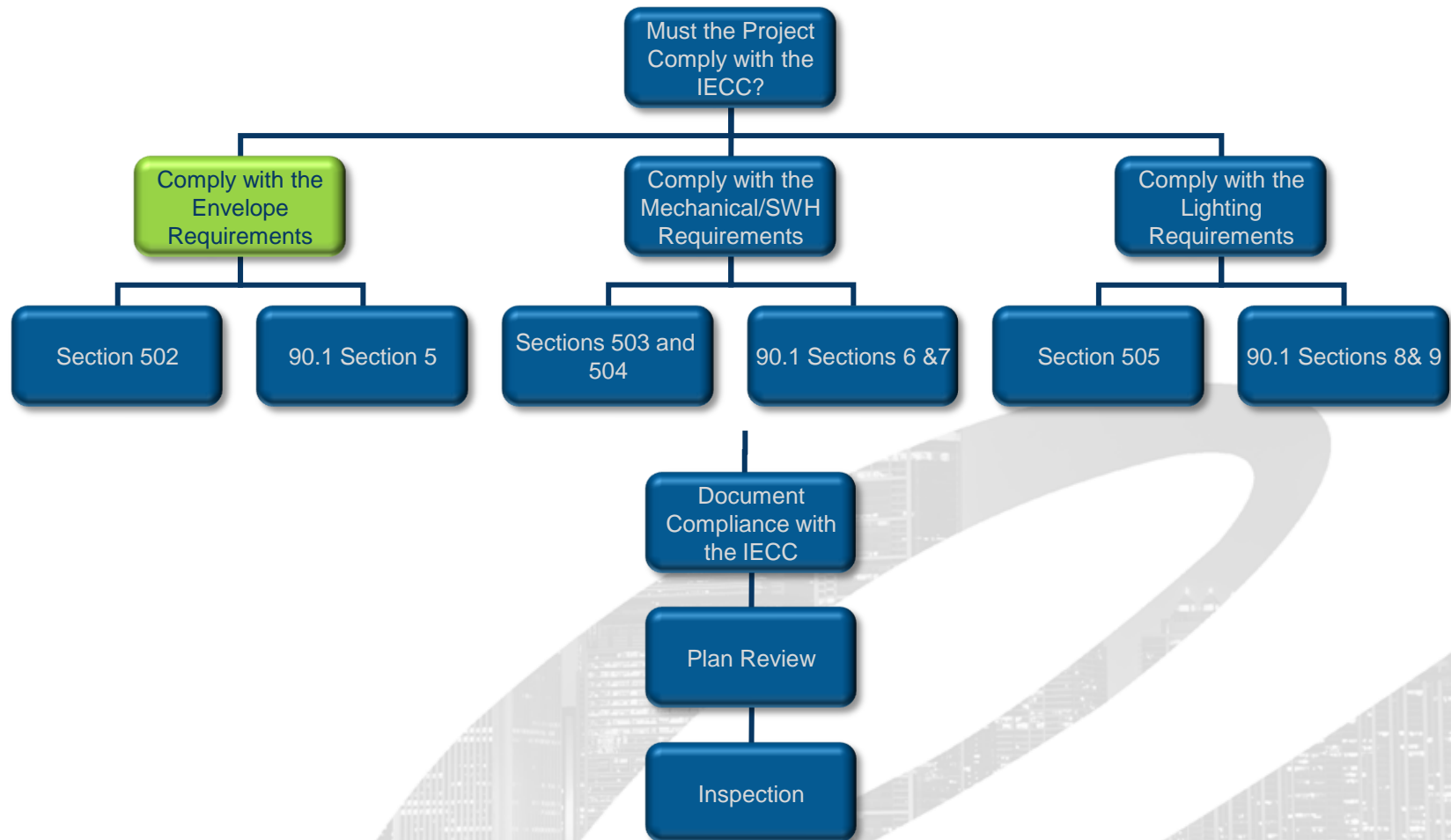
- Code Official has final authority
 1. Software, worksheets
 2. Above Code Programs
- Electronic media can be used
- Construction work for which a permit is required is subject to inspection
- Certificate is required



Compliance/Documentation/Inspections

- Code Officials Inspection: Successive and final inspections, and re-inspections if necessary
- Code Validity: Code deemed to be illegal or void shall not affect the remainder of the code
- Codes and standards considered part of the requirements of the code: Provisions take precedence
- Fees
 1. Must be paid before permit is issued
 2. Required in accordance with schedule

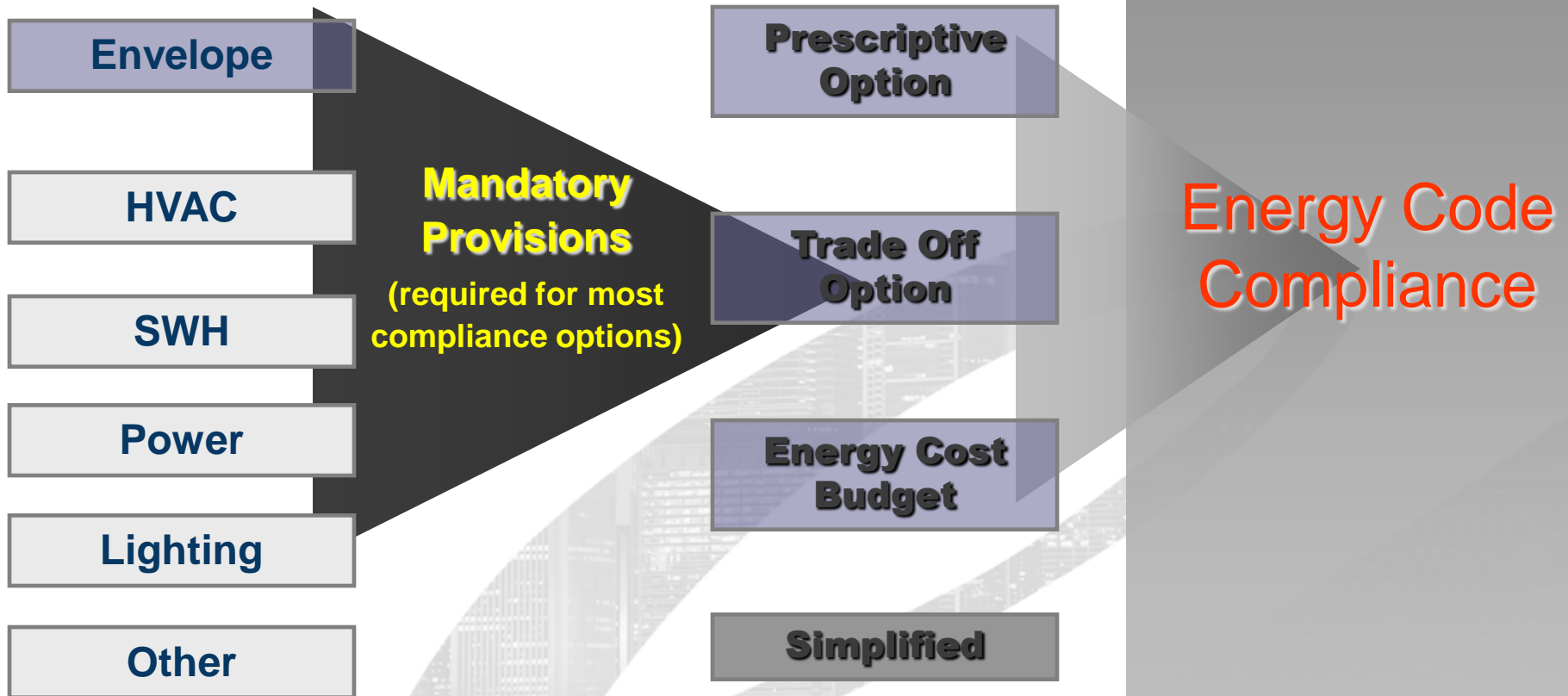
The Commercial Energy Code Compliance Process: IECC



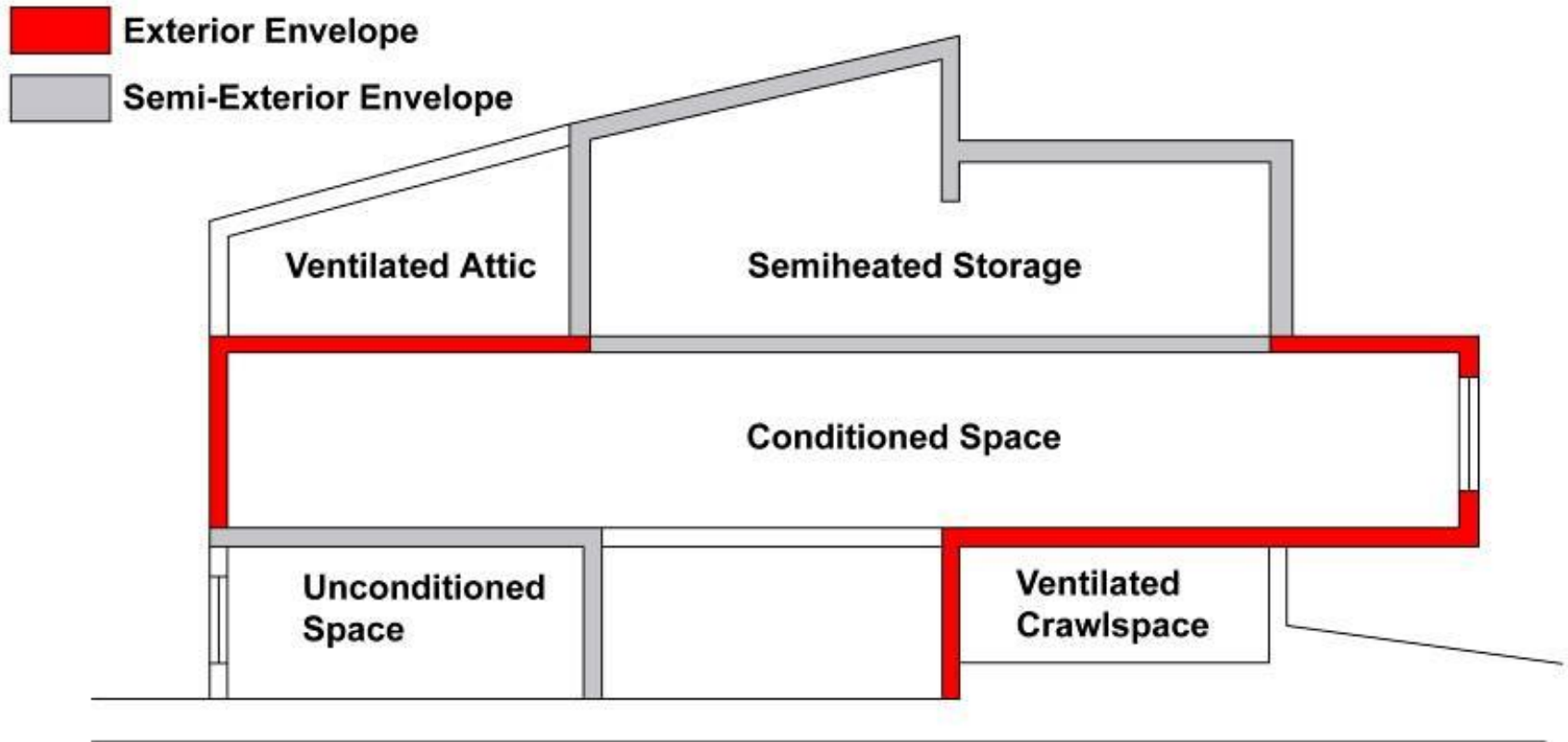
Envelope Compliance - Standard 90.1

Building System

Compliance Options



The Building Envelope



Scope

- Envelope components that enclose
 1. Conditioned space
 2. Semi heated space – Standard 90.1 Only
 - Has a heating system with a capacity $> 3.4 \text{ Btu/h}\cdot\text{ft}^2$ of floor area but is not conditioned space
- Requirements apply to three types of spaces
 1. Nonresidential
 2. Residential High Rise
 3. Semi heated – Standard 90.1 Only
- Exceptions...many

Mandatory Requirements for the Commercial Energy Code: Building Envelope

- Heated or Cooled space
- Building Envelope consists of:
 - **Fenestration**
 - Ceilings
 - Walls
 - Above grade
 - Below grade
 - Mass walls
 - Floors
 - Slab
 - Crawl space

Fenestration

- IECC and Standard 90.1 - similar mandatory
- For further details - see fenestration tables in 2009 IECC and Standard 90.1 – 2007
- Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, and skylights
- Compliance
 1. Meet or exceed maximum U-factors in table
 2. Meet or exceed minimum SHGC in table

Fenestration Area

Standard 90.1

- Total vertical fenestration area to be $< 40\%$ of gross wall area
 1. Including both fixed and operable vertical fenestration
- Total skylight area to be $< 5\%$ of gross roof area
 1. Including glass skylights, plastic skylights with a curb, and all skylights without a curb

IECC

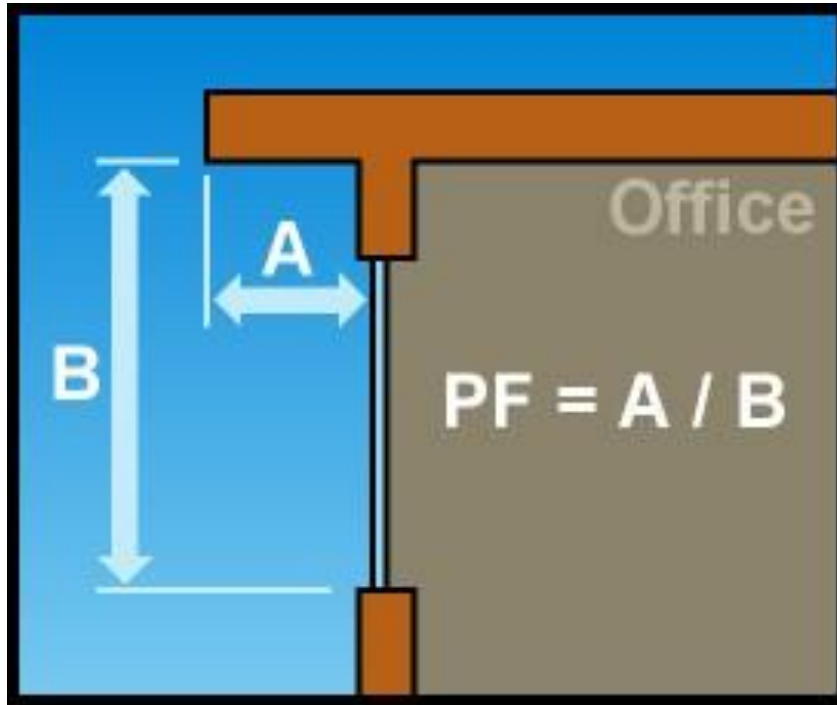
- Based on above-grade wall area (gross)
 1. Includes walls between conditioned space and unconditioned space or the great outdoors
 - Includes walls that are $> 15\%$ above grade
- Total fenestration area (includes frame and glazing)
 1. Does not include opaque door area

SHGC – Applies to Both Codes

- Vertical fenestration
 1. SHGC values < Table value for appropriate total vertical fenestration area
- Skylights
 1. SHGC values < Table value for appropriate total skylight area
- No SHGC requirements for semi heated spaces
- No criteria for Visible Light Transmittance in Prescriptive Building Envelope Option, but there are minimum criteria in the Trade-Off Option (Details in Appendix C)
- Exceptions



IECC Fenestration SHGC Requirements

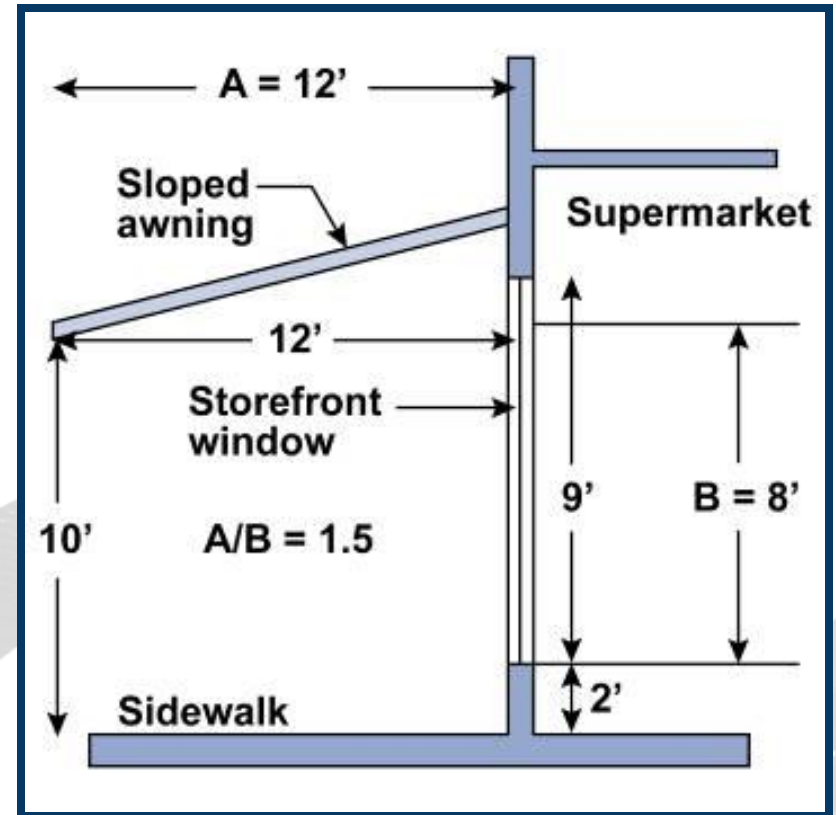


The Effect of Overhangs on Fenestration SHGC

- Overhangs allow a higher SHGC product to be installed
- Projection factor must be calculated

Standard 90.1 Overhangs

- Standard credits permanent overhangs by adjustment to SHGC
- Size of overhang is determined by projection factor



Standard 90.1 U-Factor

- Skylights – determine for a slope of 20° above the horizontal
- Labeled and certified by manufacturer
- Exceptions
 1. Glazed wall systems in vertical fenestration and skylights – may use U-factors in A.8.1
 2. A8.2 acceptable for other vertical fenestration
 3. A7 acceptable for opaque doors
 4. ANSI/DASMA 105 acceptable for garage doors

IECC Fenestration U-Factor (303.1.3)

How Do You Meet the Requirement?

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
0.51	0.2
Condensation Resistance	_____
51	
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>	

- Fenestration product rating in accordance with national testing requirements
- Labeled and certified by the manufacturer
- Default Glazed Fenestration U-factor Table 303.1.3(1-3)

IECC and Standard 90.1 Fenestration Tables

	Climate Zone 4	Climate Zone 5
U-Factor	.40	.35
Curtain Wall/Storefront U-Factor	.50	.45
Entrance door U-Factor	.85	.80
SHGC: $PF < .25$.40	.40
SHGC: $.25 < PF < .5$	NR	NR
Skylight U Factor	.60	.60
Skylight SHGC	.40	.40



For further examples please see Standard 90.1 or IECC reference documents.

Standard 90.1 SHGC Fenestration Multipliers

Projection Factor	SHGC Multiplier (All Other Orientation)	SHGC Multiplier (North-Oriented)
0-.10	1.00	1.00
>.10-.20	.91	.95
>.20-.30	.82	.91
>.30-.40	.74	.87
>.40-.50	.67	.84
>.50-.60	.61	.81
>.60-.70	.56	.78
>.70-.80	.51	.76
>.80-.90	.47	.75
>.90-1.00	.44	.73



For further examples please see Standard 90.1 or IECC reference documents.

Opaque Doors Standard 90.1 Requirements

- Meet or exceed maximum U-factors in appropriate table for climate zone

Opaque Elements	Nonresidential		Residential		Semih heated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.048	R-20 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.055	R-13.0 + R-13.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151*	R-5.7 ci*	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	Opaque Doors Swinging Non-Swinging		U-0.700 U-1.450	
Steel Joist	U-0.350					
Wood Framed and Other	U-0.282					
Slab-On-Grade Floors						
Unheated	R-10.0	NR				
Heated	R-15.0	NR				
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Opaque Doors IECC – Table 502.2.7



- Doors having $< 50\%$ glass area
- Swinging doors
 1. Meet U-factor requirement
- Roll-up or sliding doors
 1. Climate zones 1 - 3: U-1.45
 2. Climate zones 4 including Marine - 8: U-0.50

Fenestration U-Factor – Curtain Wall IECC and Standard 90.1



- By definition:
Fenestration products
used to create an
external nonload-bearing
wall that is designed to
separate the exterior and
interior environments

Fenestration U-Factor – Storefront

IECC and Standard 90.1



- By definition: A nonresidential system of doors and windows mullled as a composite fenestration structure that has been designed to resist heavy use. Storefront systems include, but are not limited to, exterior fenestration systems that span from the floor level or above to the ceiling of the same story on commercial buildings.

Fenestration U-Factor – Entrance Door

IECC and Standard 90.1



- By definition: Fenestration products used for ingress, egress and access in nonresidential buildings, including but not limited to, exterior entrances that utilize latching hardware and automatic closers and contain over 50% glass specifically designed to withstand heavy use and possibly abuse

Fenestration and Doors – ASHRAE 90.1

- U-factors
 1. NFRC 100 or
 2. Assemblies listed in Appendix A
- SHGC
 1. NFRC 200 or
 2. Assemblies listed in Appendix A
- Visible Light Transmittance
 1. NFRC 200 when building envelope trade-off option is used



Skylight U-Factor / SHGC IECC and Standard 90.1

- Limited to $\leq 3\%$ of Roof Area
- U-factor and SHGC Based
- No SHGC requirements in Climate Zones 7-8



Visible Light Transmittance

- A measure of the amount of visible light that passes through fenestration
- Affected by:
 1. composition of the glass
 2. coatings
 3. internal shading devices
- Relationship between VLT and SHGC
 1. Daylighting without excessive solar gain— VLT at least 1.2 x SHGC



Insulation

Insulation serves many purposes, including:

- **Conserving energy by reducing heat loss or gain.**
- **Controlling surface temperature**
- **Facilitating temperature control**
- **Preventing condensation**
- **Preventing or reducing damage to equipment from exposure to fire or corrosive atmospheres**
- **Controlling noise**

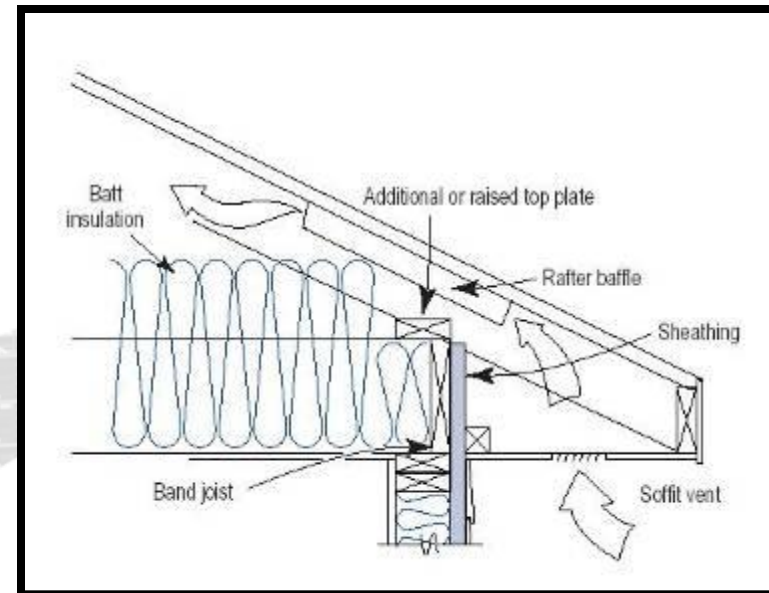


Product Information and Installation Requirements

- Labeling of Building Envelope Insulation (*Section 5.8.1.1*)
- Compliance with Manufacturers' Requirements (*Section 5.8.1.2*)
- Loose-Fill Insulation Limitation (*Section 5.8.1.3*)
- Baffles (*Section 5.8.1.4*)
- Substantial Contact (*Section 5.8.1.5*)
- Recessed Equipment (*Section 5.8.1.6*)
- Insulation Protection (*Section 5.8.1.7*)
- Location of Roof Insulation (*Section 5.8.1.8*)
- Extent of Insulation (*Section 5.8.1.9*)

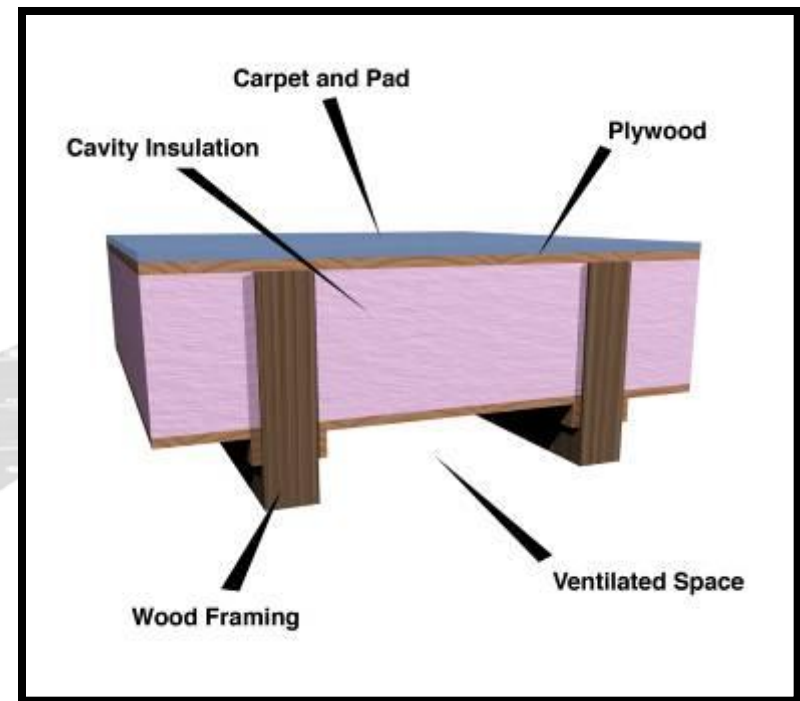
Insulation Installation

- Per manufacturer's instructions
- Achieve rated R-value
- No open-blown or poured loose-fill insulation when ceiling slope is $> 3/12$
- If eave vents installed
 1. Provide baffling of air vents to deflect incoming air above the surface of the insulation
- Exception
 1. Metal buildings – if roof and wall insulation is compressed between roof or wall skin and the structure



Insulation - Substantial Contact

- Install insulation in a permanent manner in substantial contact with inside surface
- Flexible batt insulation in floor cavities
 1. Supported in a permanent manner by supports no more than 24 in. on center (o.c.)



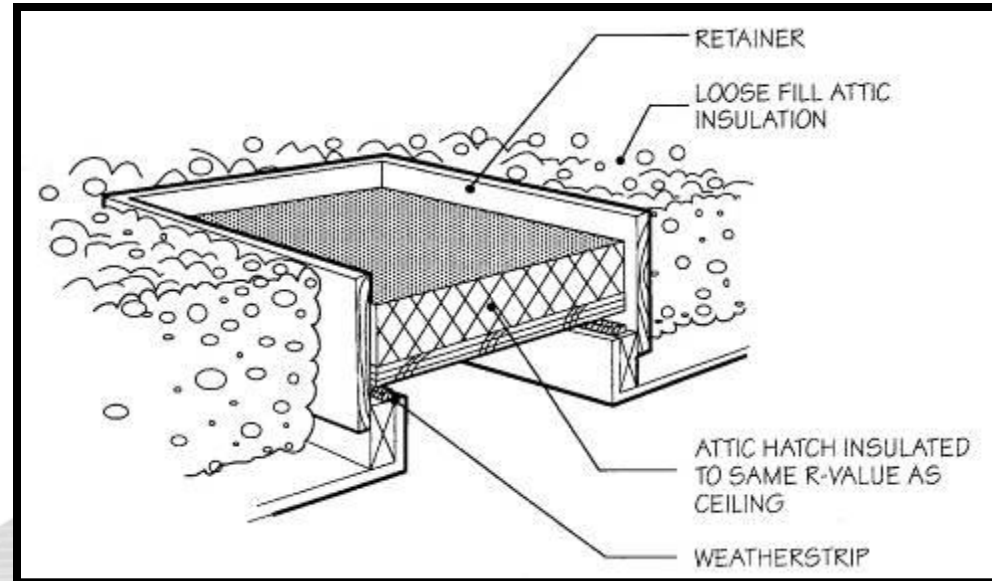
Recessed Equipment

- Do not recess equipment to affect insulation thickness
 1. Lighting fixtures
 2. HVAC equipment (includes wall heaters, ducts, and plenums)
 3. Other
- Except when
 1. Total combined area affected (include necessary clearances) is $< 1\%$ of opaque area of the assembly, **OR**
 2. Entire roof, wall, or floor is covered with insulation to the full depth required, **OR**
 3. Effects of reduced insulation are included in area-weighted calculations

Insulation Protection

○ Insulation Protection

1. Cover exterior insulation with protective material
 - Sunlight
 - Moisture
 - Landscaping operations
 - Equipment maintenance
 - Wind
2. Access to attics and mechanical rooms without damaging or compressing insulation
3. Insulation materials in ground contact to have a water absorption rate $\leq 0.3\%$ (ASTM C272)



Wall R-Value – Mass Walls - IECC



- Walls weighing at least 35 lbs/ft² of wall surface area, or
- 25 lbs/ft² of wall surface area if material weight is $\leq 120 \text{ lb/ft}^3$

Mass Wall Comparison

IECC

- Climate Zone 4 except marine -
Can use integral insulation instead of R-5.7 ci
 1. Concrete block walls must comply with ASTM C 90, and
 2. UngROUTED or partially grouted @ 32 inch. o.c. or less vertically or 48 inch. o.c. or less horizontally, and
 3. UngROUTED cells must be filled with insulation material \leq of 0.44 Btu-in./h-ft² F
- Climate Zone 1
 1. No insulation required for mass walls

Standard 90.1

Heat capacity determined from Table A3.1B or A3.1C

R-value is for continuous insulation or when uninterrupted by framing other than metal clips no closer than 24 in. o.c. horizontally and 16 in. o.c. vertically

1. Exception – requirement of U-0.151

Other Above Grade Walls – Standard 90.1

1. Metal building wall R-value
 - for insulation compressed between metal wall panels and the steel structure
2. Steel-framed wall R-value
 - for uncompressed insulation installed in the cavity between steel studs
3. Wood-framed and other R-value
 - for uncompressed insulation installed in the cavity between wood studs; also acceptable to be continuous insulation uninterrupted by studs

Below Grade Walls

What is a below grade wall?

Basement or first-story walls $\geq 85\%$ below grade

IECC

- Insulation must extend down 10 ft from the outside finished grade level or to the level of the floor, whichever is less
- Heated slabs installed below grade:
Below grade walls must meet exterior insulation requirements for perimeter insulation according to heated slab-on-grade construction

Standard 90.1

- Meet or exceed values in appropriate table for climate zone
- R-value is for continuous insulation
- If framing is used, compliance is based on maximum assembly C-factor

Floors Over Outdoor Air or Unconditioned Space

- Three Types of floors over unconditioned space in both energy codes

1. Mass
2. Steel
3. Wood Frame



Floors Over Outdoor Air or Unconditioned Space

IECC

- Steel/Wood Frame
 - Insulation installed between framing
- Mass Floors
 1. Materials weighing 35 lbs/ft², or
 2. 25 lbs/ft² if material weight is \leq 120 lbs/ft³
 3. Insulation installed continuously

Standard 90.1

- Steel-joist floors/Wood framed
 1. R-value is for uncompressed insulation or spray-on insulation, but is also acceptable for continuous insulation
- Mass floors
 1. R-value is for continuous insulation
 2. If framing is used, compliance is based on maximum assembly U-factor

Slab-on-Grade Floors

IECC

- Unheated slab – insulation required in Climate Zones 4-8
- Heated slabs – insulation required in all Climate Zones

Standard 90.1

- Meet or exceed values in appropriate table for climate zone (includes R-value and depth or width of insulation)
- Be installed around the perimeter to the distance specified
 1. **Inside foundation wall** – extend downward from top of slab a minimum distance specified or to the top of the footing, whichever is less
 2. **Outside foundation wall** – extend from top of the slab or downward to at least the bottom of the slab and then horizontally to a minimum distance specified

Roof Insulation – Applies to both codes

- Meet or exceed minimum R-value in table for climate zone
- Skylight curbs insulated to level of roofs with insulation entirely above deck or R-5, whichever is less
- Three types of roofs are defined:
 1. Roofs with insulation entirely above deck
 - R-value is for continuous insulation
 - Interruptions for mechanical equipment $\leq 1\%$ of surface of the total roof area

Roof Insulation –Standard 90.1

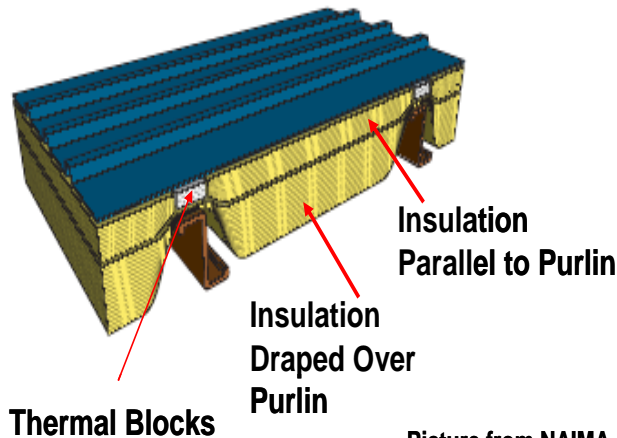
2. Metal building roofs:

- First value is for insulation
 - draped over purlins and then compressed when metal spanning members attached or
 - hung between purlins provided there's a min. of 1" thermal break between purlins and metal spanning members
- Second value is for double-layer installations with insulation installed parallel to the purlins

3. Attics and other roofs

- R-value is for insulation installed both inside and outside the roof or entirely inside the roof cavity

3. Metal Roofs – IECC/Standard 90.1



Picture from NAIMA

Standard 90.1 Requirements

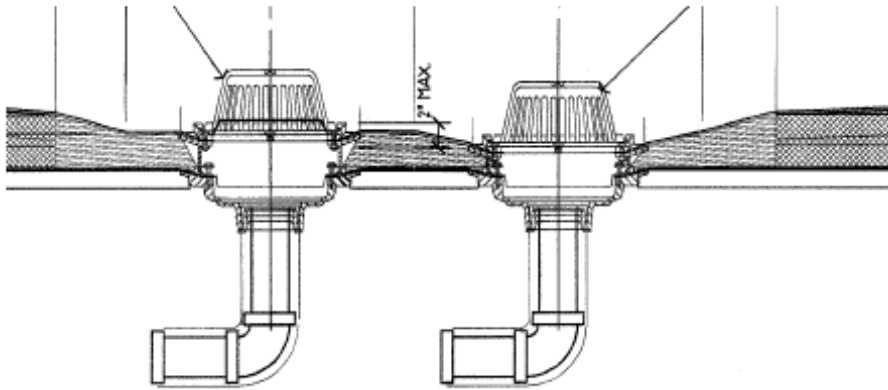
First value is for insulation draped over purlins and then compressed when metal spanning members attached or hung between purlins provided there's a min. of 1" thermal break between purlins and metal spanning members

Second value is for double-layer installations with insulation installed parallel to the purlins

IECC Requirements

- R-5 thermal blocks required on all metal buildings or must use U-factor Compliance Method
- Climate Zones 2-8 require two layers of insulation
 1. CZ 2-5 and marine R: R-13+R-13
 2. CZ 6-7: R-13+R-19
 3. CZ 8: R-11+R-19
- Example (R-13+R-19):
 1. R-13 draped perpendicularly to the purlins
 2. R-19 running parallel to the purlins supported by the R-13

Roof – Insulation Completely Above Deck - IECC



- Insulation considered continuous (*C/I*)
- Insulation thickness can vary $\leq 1"$ and area weighted U-factor meets the requirements of Table 502.2(1)

Roof Insulation - Above Suspended Ceilings

IECC

- Will not count for code compliance
- Will not comply with Section 502.4.3 – “Sealing of the building envelope” because... NO Air Barrier is established!

Standard 90.1

- Not installed on a suspended ceiling with removable ceiling panels



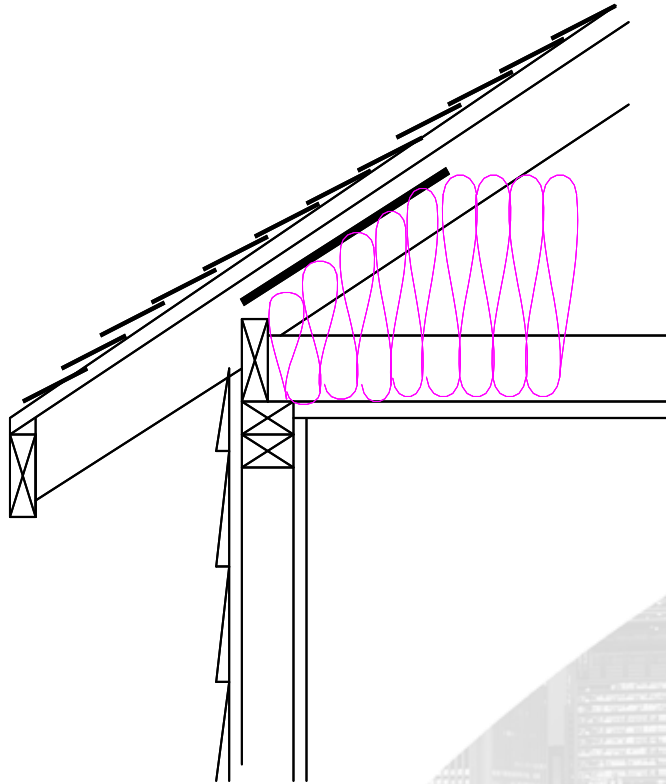
IECC - Roof R-Value and U-Factor

Roof R-values and U-factor requirements are based on assembly type/insulation placement



- Insulation entirely above deck
- Metal buildings
- Attic and other

IECC - Roof R-Value – Ceilings with Attic Spaces



- Install insulation between framing
- R-38 in most Climate Zones
- R-30 in Climate Zones 1 and R-49 in Climate Zone 8

High Albedo Roofs - Standard 90.1

- Roofs with a minimum total solar reflectance of 0.70 and a minimum thermal emittance of 0.75 or a minimum Solar Reflective Index of 82, other than roofs with ventilated attics or roofs of semi heated spaces or roofs over conditioned spaces that are not cooled spaces shall comply with the values in Table 5.5.3.1.

Basically, “cool roofs” are allowed to have less insulation.

Standard 90.1/IECC Prescriptive Tables

Refer to Your Code Books

Air Infiltration and Sealing the Envelope

Placeholder for multimedia slide.

- <http://www.youtube.com/watch?v=hKbwtVPa-V8>

Air Leakage - Building Envelope Sealing

- Joints around fenestration and door frames
- Junctions between walls
 1. and foundations
 2. at building corners
 3. and structural floors or roofs
 4. and roof or wall panels
- Openings for utility services through roofs, walls, and floors
- Site-built fenestration and doors
- Building assemblies used as ducts or plenums
- Joints, seams, and penetrations of vapor retarders
- All other openings in the building envelope

Mandatory Requirements – Sealing of the Building Envelope IECC and Standard 90.1

- All penetrations, openings, joints and seams in the building envelope must be sealed. Materials that can be used include:
 1. Caulking
 2. Gasketing
 3. Tapes
 4. Moisture vapor-permeable wrapping material
- Sealing materials spanning joints between dissimilar materials must allow for expansion and contraction

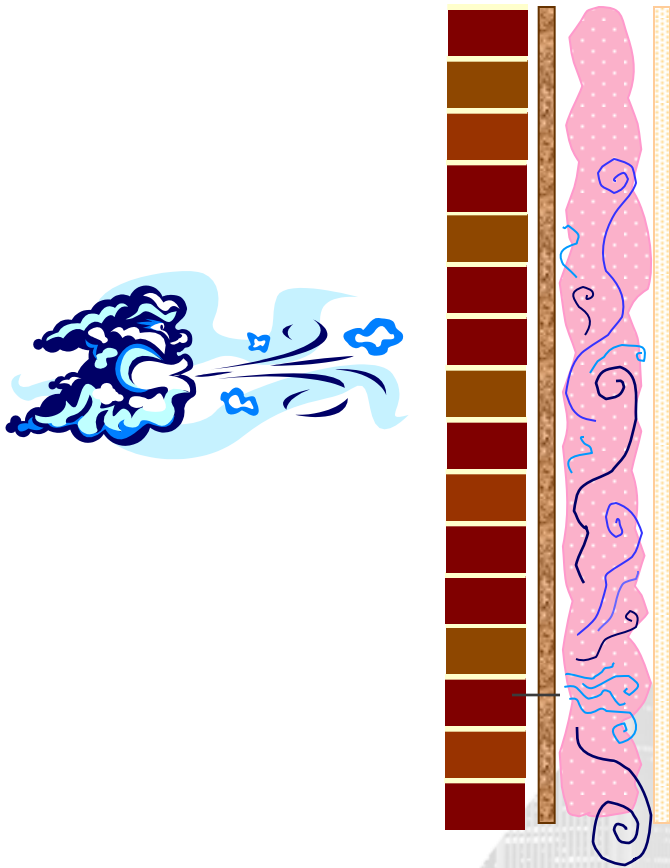


Air Leakage

- Seal, caulk, gasket, or weather-strip
 1. Openings and joints in building envelope
 2. Fenestration and doors per NFRC 400
 3. Loading docks in climate zones 4-8
 4. Vestibules and doors separating conditioned space from exterior



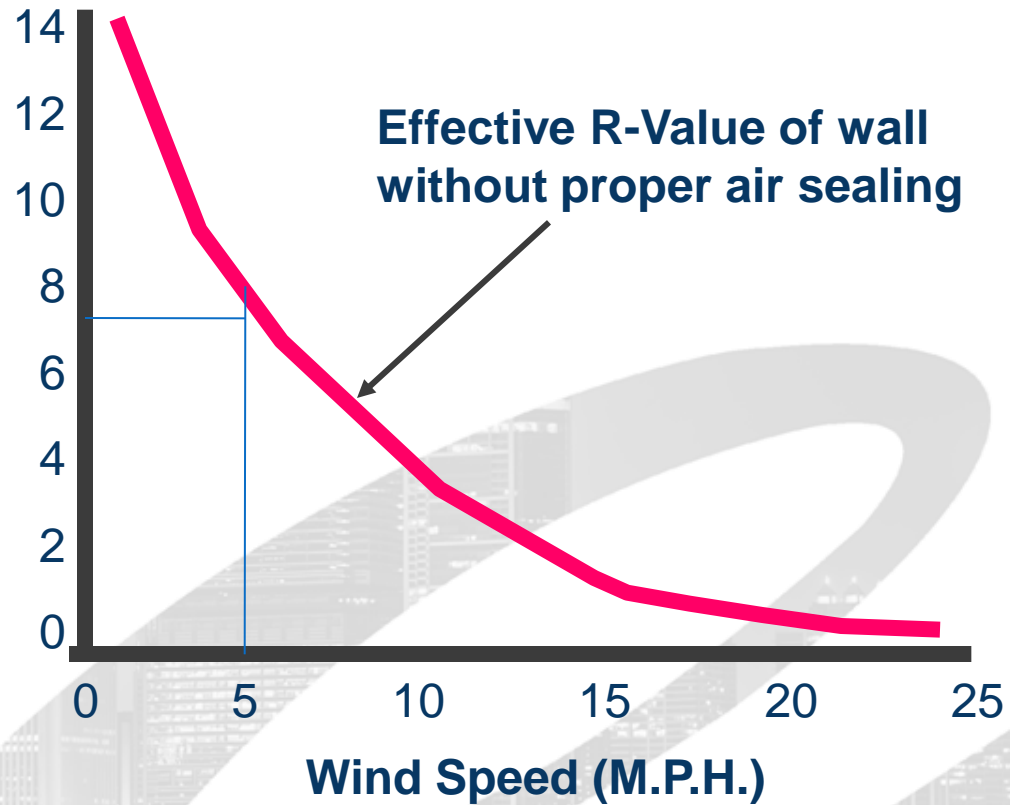
Air Infiltration



Windwashing- air movement within the wall cavity that **reduces** the installed R-value.

Effect of Wind on Installed R-Value

Wall System
Installed R-Value
(°F x ft.² x h/BTU)



*Test data by Holimetrix. ASTM E283, ASTM E1424, C976

Why Is Air Leakage Important?

- Definition: Uncontrolled Air Movement Into/Out of Buildings
- Moisture Problems
 1. Much More Water Vapor Is Carried by Escaping Air Than by Diffusion (200:1)
- Energy Penalties - Sensible and Latent
- HVAC Systems Might Not Operate As Designed
- Allows Migration of Pollutants (By Air Pressures)

Why Limit Vapor and Air Transfer?

- Air Movement Can Lead to Several Problems
 1. Moisture-related Building Damage
 2. Energy Penalties - Sensible and Latent
 3. Poorly Functioning HVAC Systems



Moisture Migration Is a Key Element in Building Deterioration

Air Barriers

- Intended to Stop Air Movement Through Envelope Components and Assemblies
- Must Be Continuous to Be Effective
- May Be Anywhere Relative to Insulation (Not Limited to Warm-in-winter Side)
- Materials May Be Selected to Act Simultaneously As Air and Water-Resistive Barrier

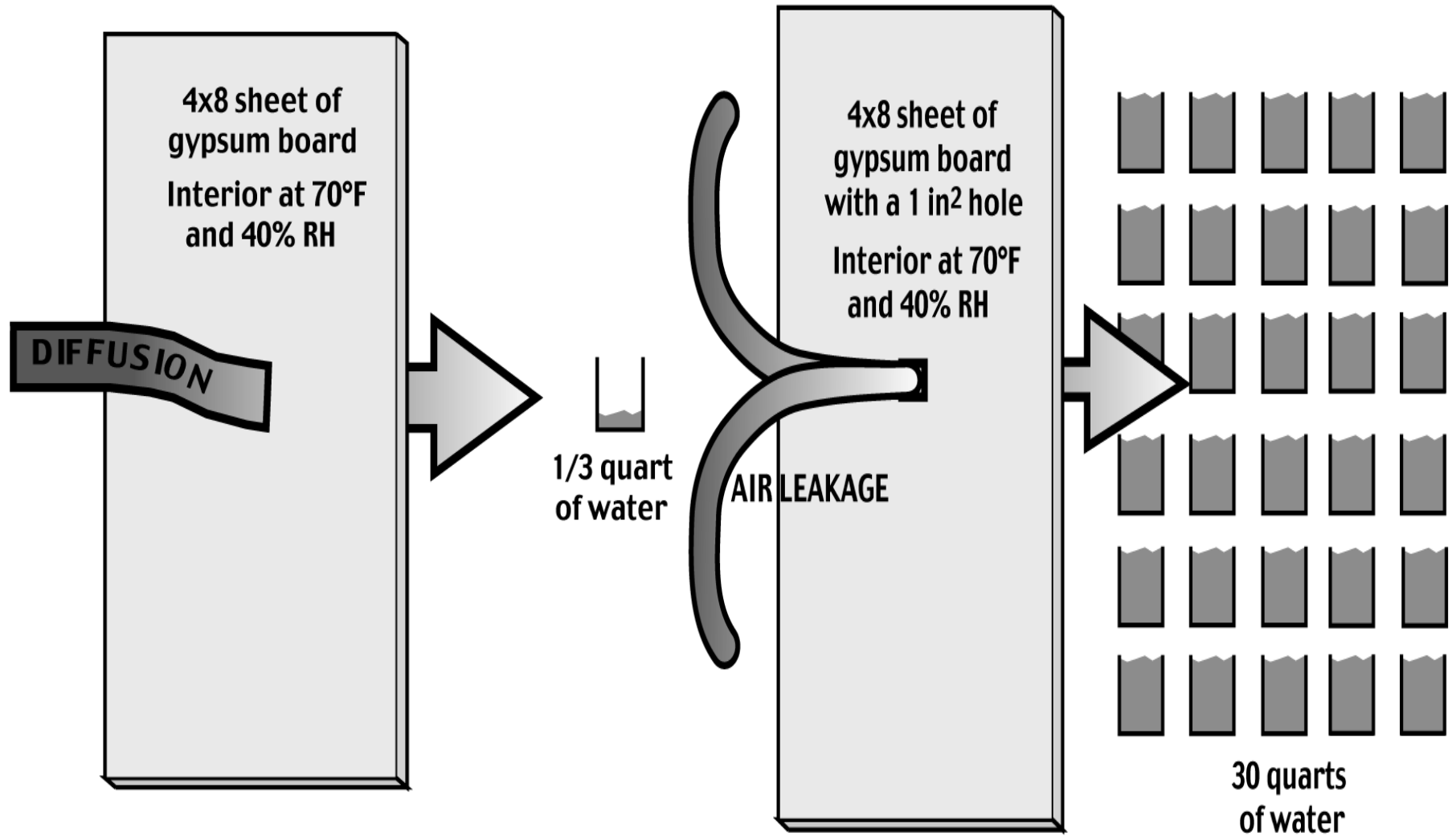
Moisture Sources in a Building

- Bulk Water
 1. Rain or Ground Water, Plumbing Failures
 2. Moves Via Leaks or Capillary Action
- Water Vapor
 1. Respiration and Perspiration
 2. Humidification Systems
 3. Plants
 4. Washing and Interior Cleaning
 5. Moves Via Vapor Diffusion or Air Movement

Controlling Moisture Movement

- Bulk Water
 1. Install Roofs, Walls, Flashings
 2. Provide Capillary Breaks
- Water Vapor
 1. Install Vapor Retarders And Air Barriers

Moisture Movement by Diffusion



Air Leakage Problems

Efflorescence: Poor air sealing in masonry construction leaves salt deposits behind from uncured concrete.



Air Leakage Problems

Spalling: Water enters a surface and forces the surface to peel or pop off. Often causes crumbling of a structure.



Air Leakage Problems

Ice Formation: Water vapor exits the surface because of poor air sealing and causes ice to form.

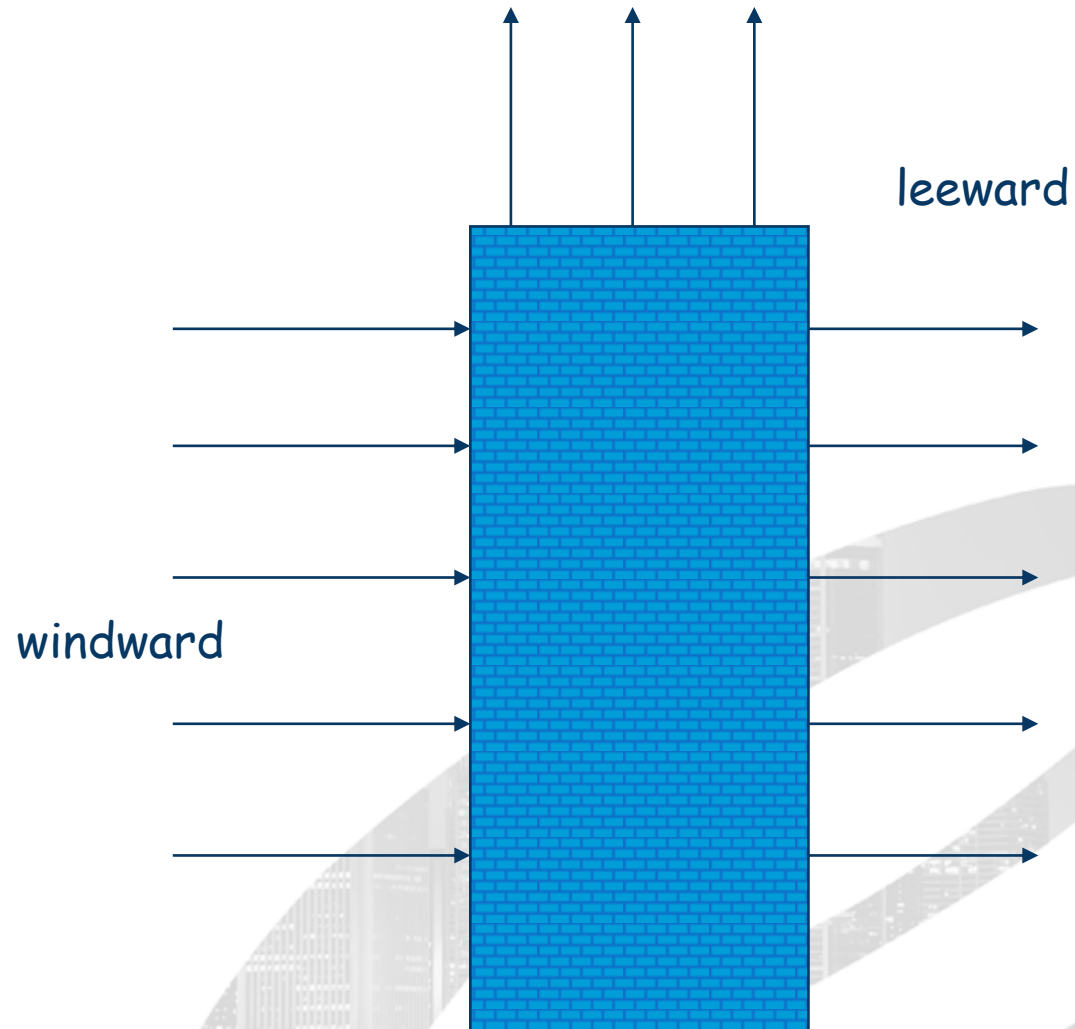


Effects of Air Leakage

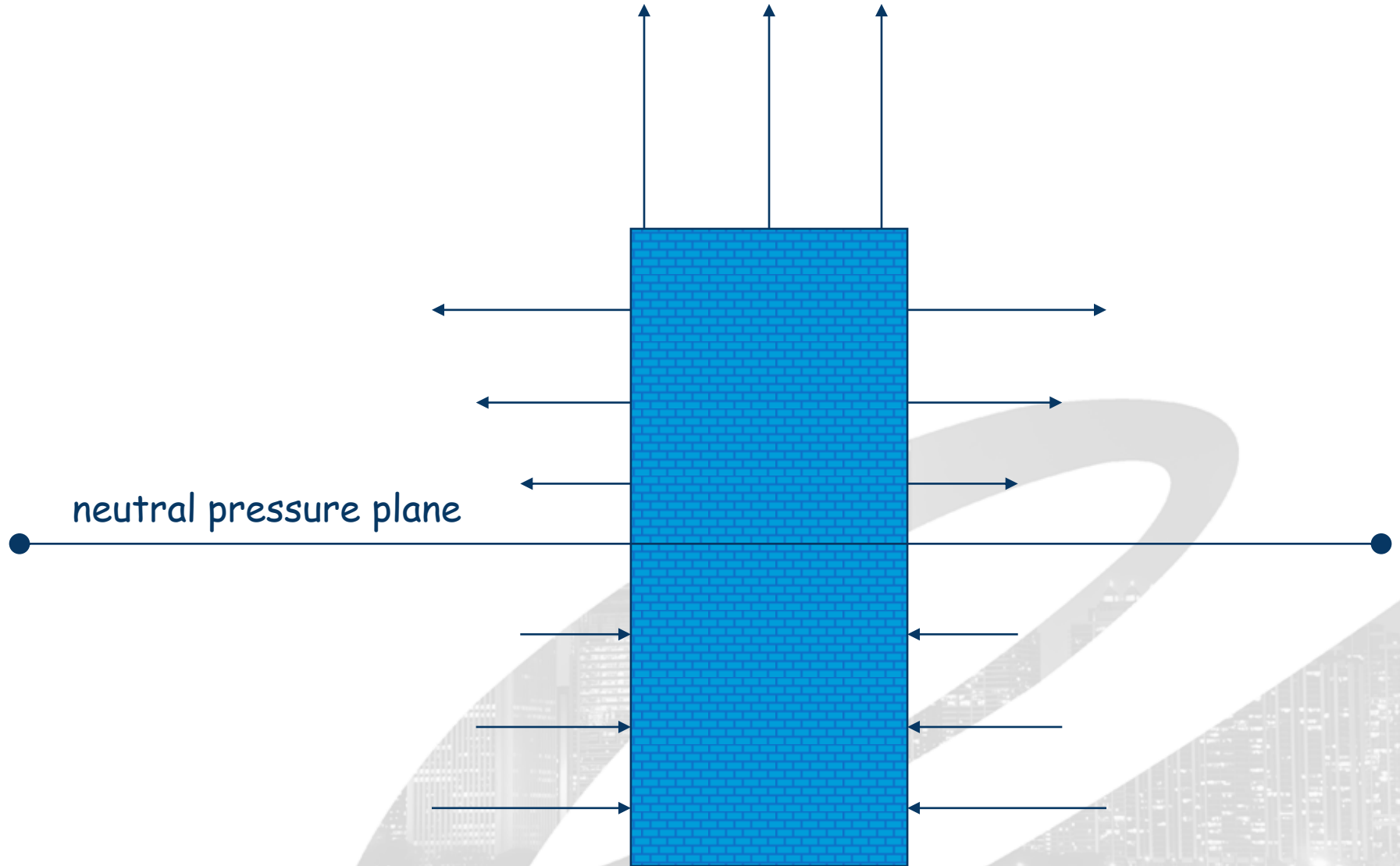
Air leakage, or infiltration, occurs when outside air enters a house uncontrollably through cracks and openings. Properly air sealing such cracks and openings in your home can significantly reduce heating and cooling costs, improve building durability, and create a healthier indoor environment.



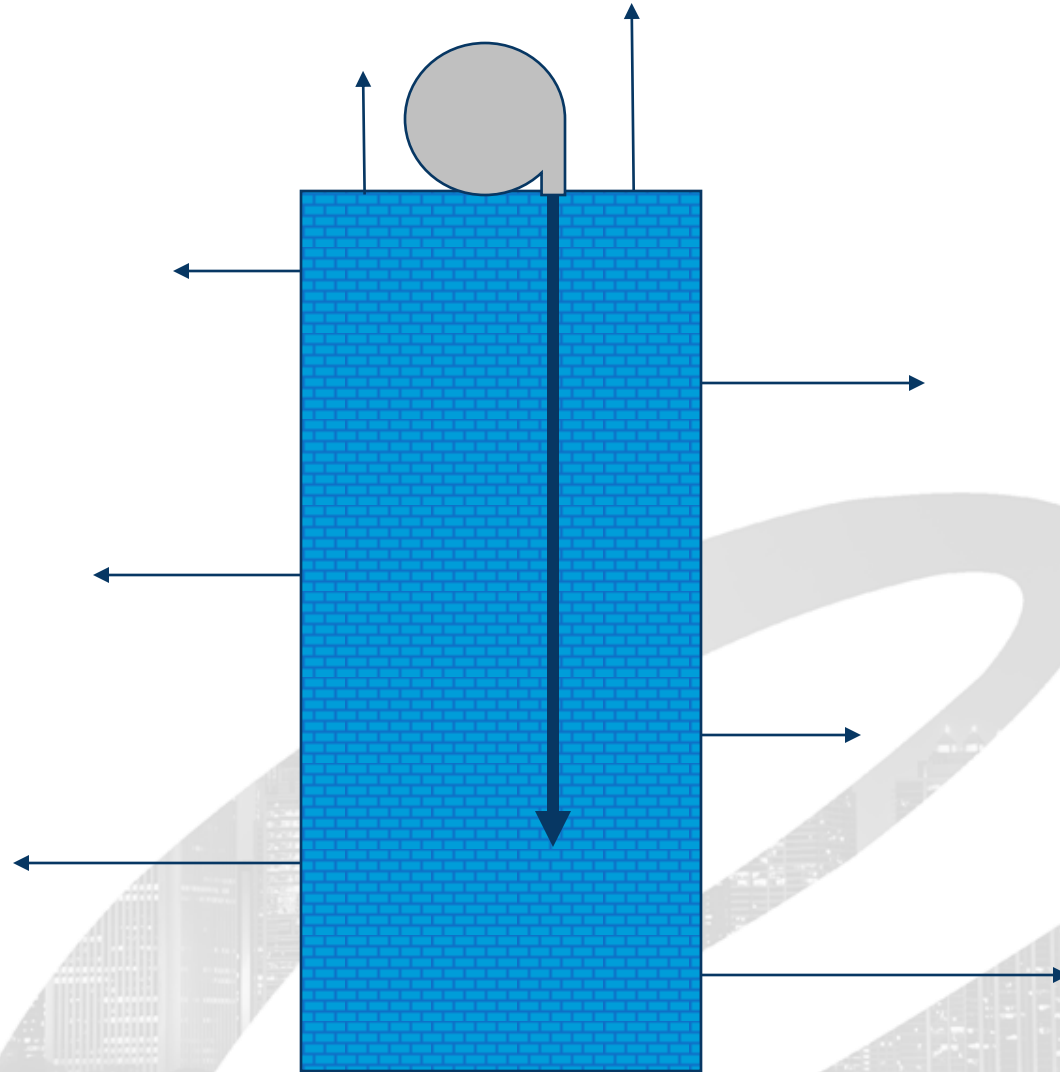
Wind



Stack Effect

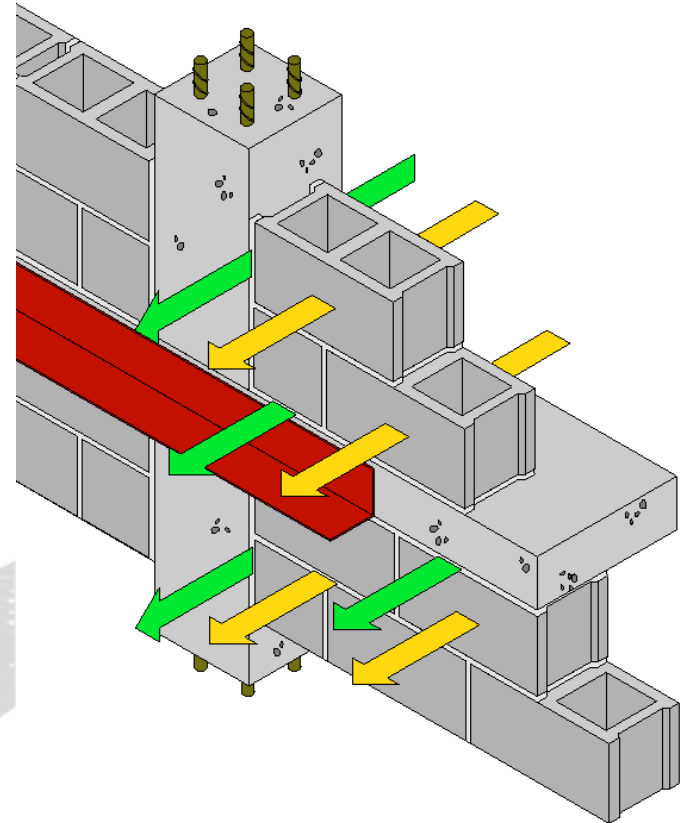


Mechanical Pressurization



Pathways

- Through Connections
 1. Foundation/Wall
 2. Floor/Wall
 3. Wall/Window
 4. Wall/Roof
- Through Materials
 1. Concrete Blocks
 2. Mortar Joints



Limiting Air Leakage Pathways

- Materials and Connections Between Materials Must:
 1. Stop Air
 2. Withstand Jobsite Abuses
 3. Withstand Forces of Wind and Pressure (Structural Support)
- Penetrations Must Be Sealed
- Functional Penetrations Must Be Dampened

Types of Air Barrier Material

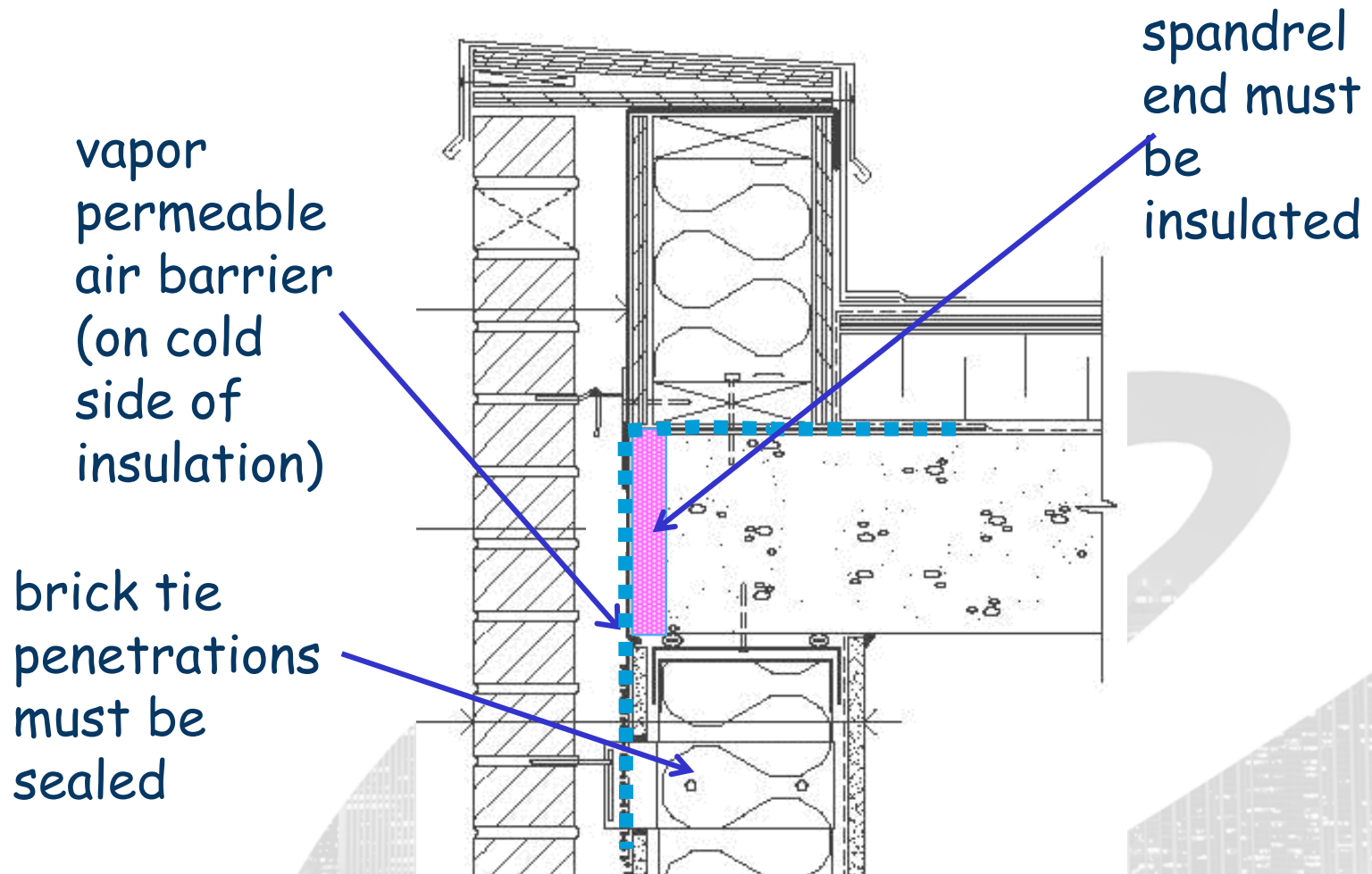
- Sheet Goods
- Films
- Peel-and-stick
- Trowel-on, Spray-on

Important Places to Insulate

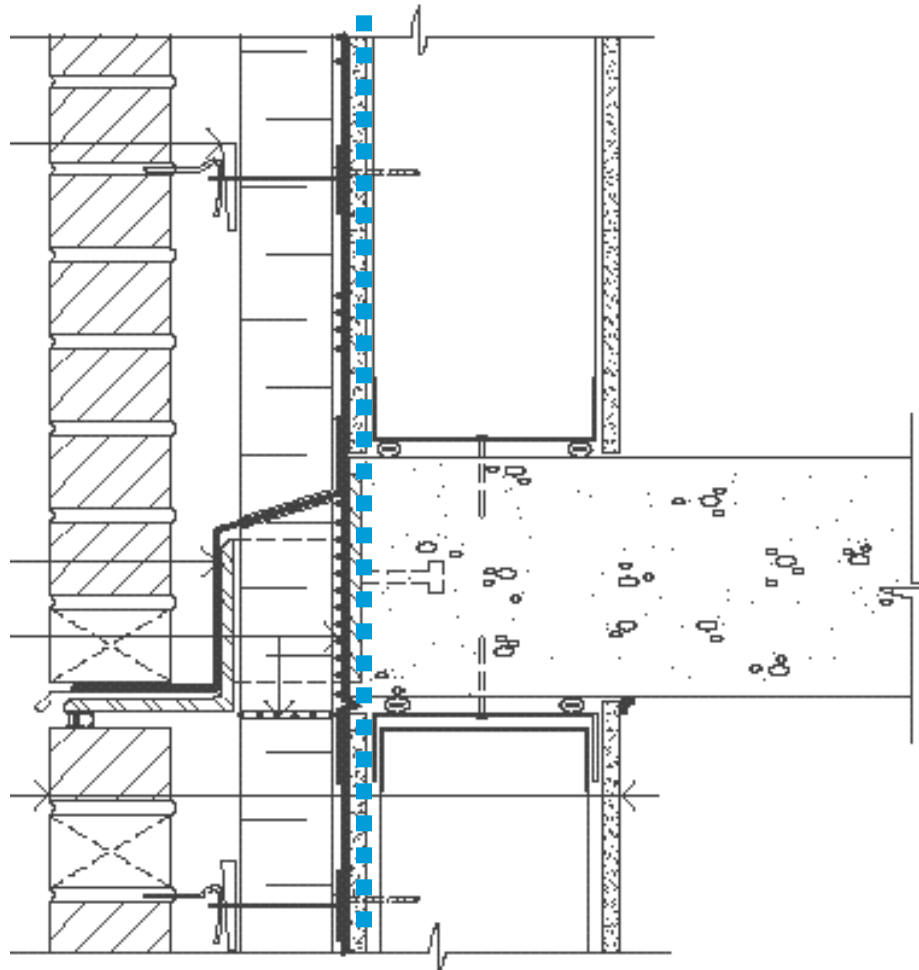
You can reduce your buildings heating and cooling costs through proper insulation and techniques. These techniques will also make your building more comfortable.



Parapet - Attaching Roof to Wall

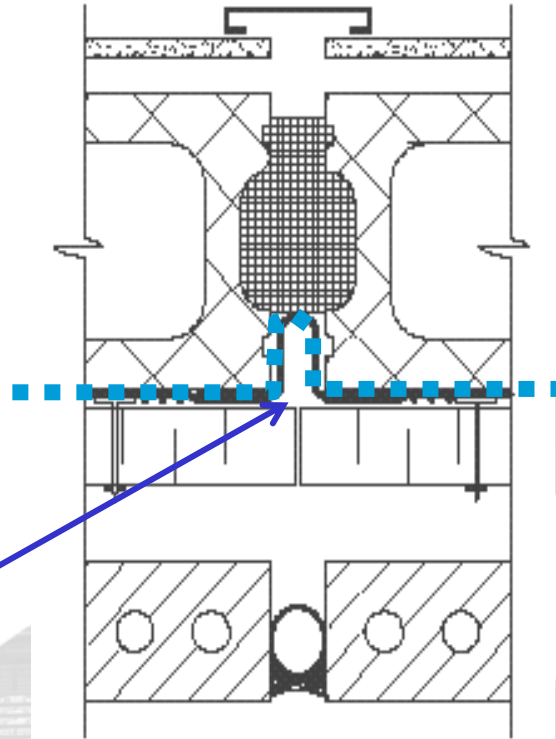


Shelf Angle



Expansion Joint

allow for
movement,
or select
materials with
high elasticity



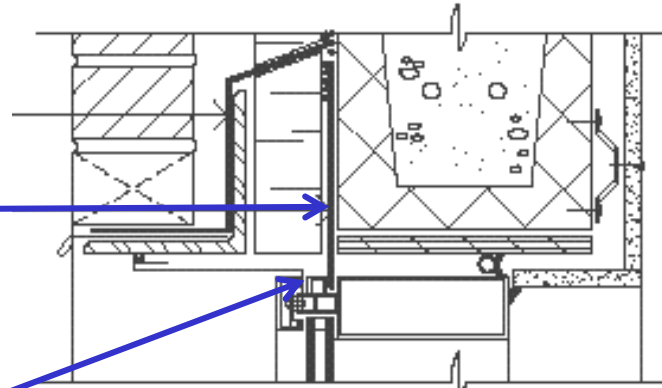
Windows - Complete the Connections

air spaces must be filled



Window Connections

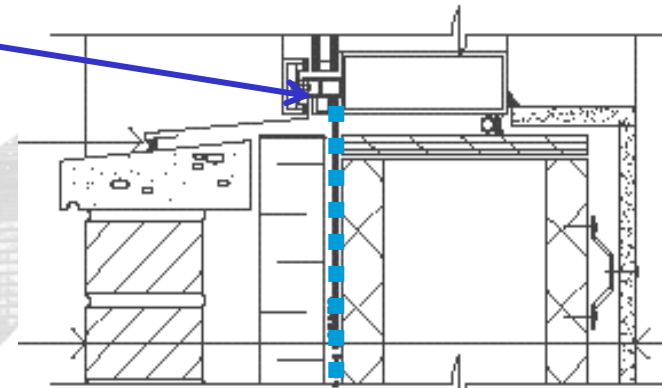
transition sheet



head

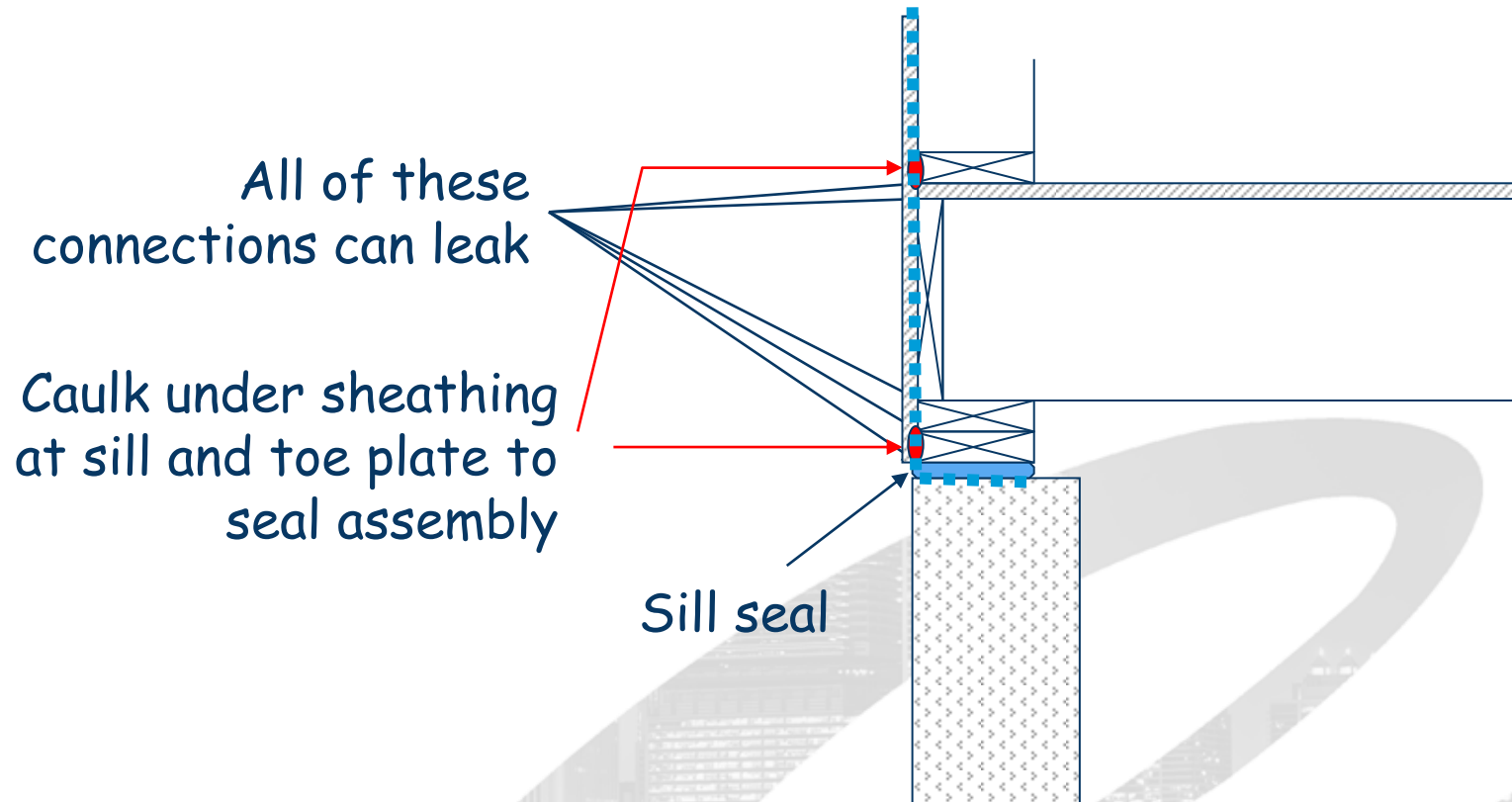
clamp tight to
window frame

similar for jamb

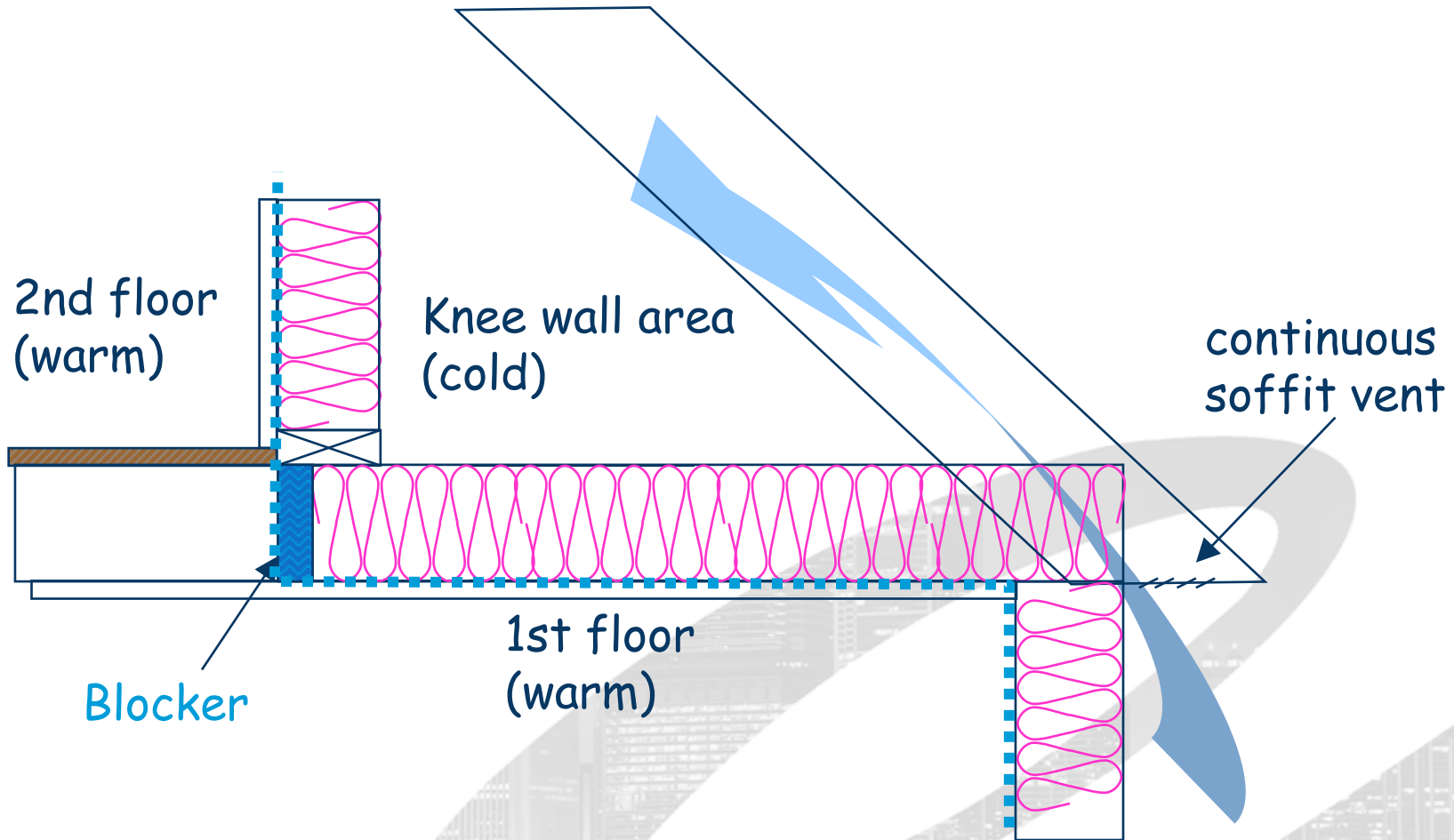


sill

Wood Framing - Air Seal at Foundation/Sill



Small Office - Cape Style



Air Sealing for Vestibules, Loading Docks and other Entrances

Both the 2009 IECC and Standard 90.1 require air sealing around Vestibules and Loading Docks. Air infiltration in these areas can be very problematic for commercial buildings and is important to the energy efficiency of the building as a whole.

Mandatory Requirements – Vestibules IECC and Standard 90.1

IECC

- Required to reduce infiltration into spaces
- Required on entrance doors leading into spaces $\geq 3,000 \text{ ft}^2$
- Doors must have self-closing devices
- Exceptions
 1. Buildings in Climate Zones 1 and 2
 2. Doors from a guest room or dwelling unit
 3. Doors used primarily for vehicular movement, material handling and adjacent personnel doors

Standard 90.1

- Required in
 1. Climate Zones 3-4 for entrances in >4 story buildings $> 10,000 \text{ ft}^2$
 2. Climate Zones 5-8 for entrances in buildings $> 1000 \text{ ft}^2$
- Vestibules must have:
 1. Self-closing doors
 2. Interior and exterior doors not open at the same time
 3. Distance between interior and exterior doors not $< 7 \text{ ft}$ when in closed position (remember ADA!)

Air Leakage - Loading Dock Weatherseals – IECC and Standard 90.1

- In climate zones 4-8
 1. Cargo doors and loading dock doors equipped with weatherseals
 - To restrict infiltration when vehicles are parked in the doorway



Mandatory Requirements – Recessed Lighting IECC Section 502.4.8

All recessed luminaires installed in the building envelope

- Type IC rated and sealed with gasket or caulk between housing and interior wall or ceiling covering
- Type IC rated and labeled in accordance with ASTM E 283 to allow ≤ 2.0 cfm of air movement from conditioned space to ceiling cavity

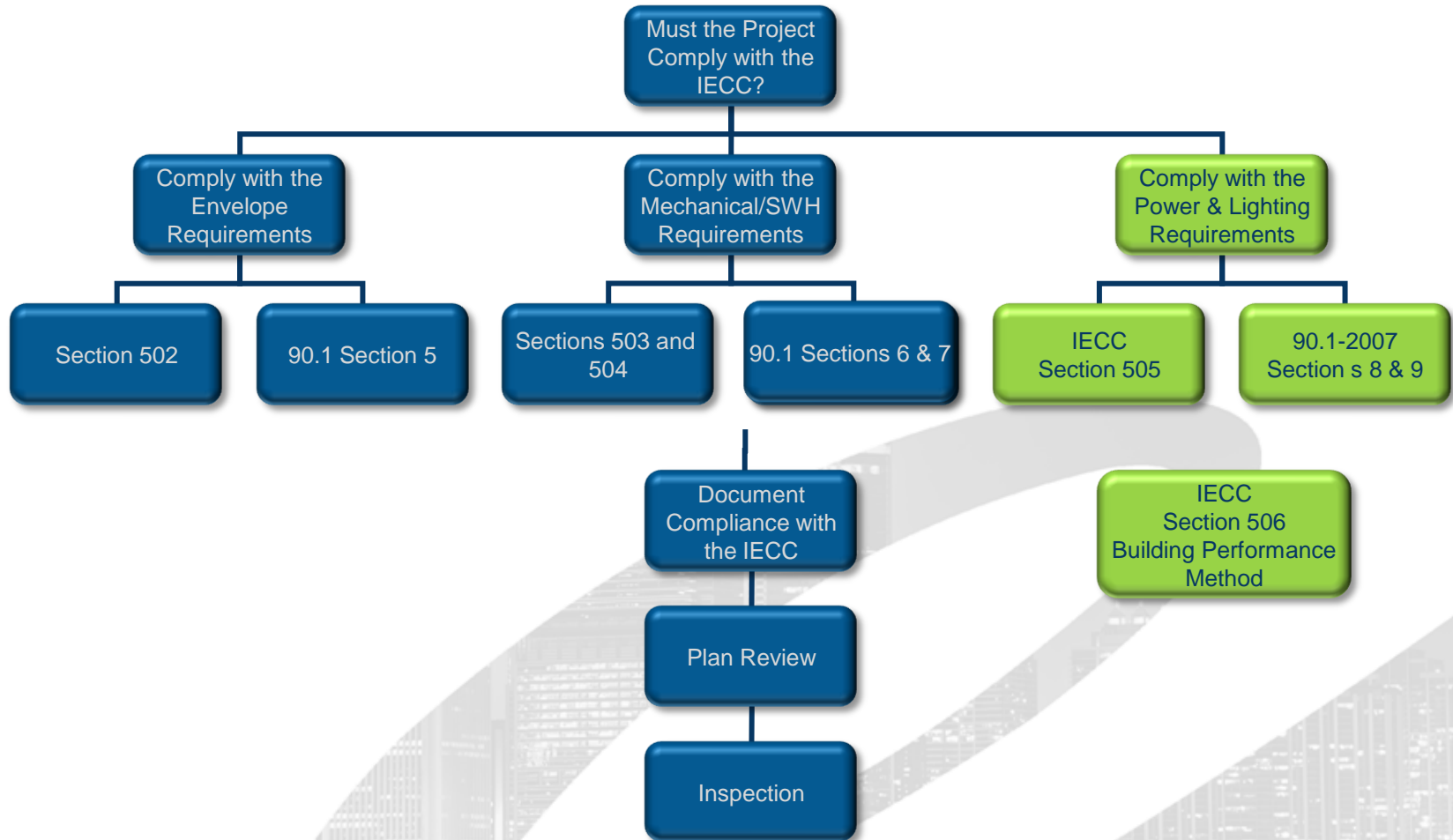


Mandatory Requirements – Outdoor Air Intakes and Exhaust Openings IECC Section 502.4.5



- Buildings ≥ 3 stories in height above grade
 - Class 1 motorized leakage-rated damper
 - Maximum leakage rate $\leq 4\text{cfm /ft}^2$ @ 1.0 inch w.g.
- Buildings < 3 stories in height
 - Gravity (nonmotorized) allowed

IECC Commercial Energy Code Compliance



Lighting Compliance for Standard 90.1

Building System

Envelope

HVAC

SWH

Power

Lighting

Mandatory Provisions

(required for most compliance options)

Compliance Options

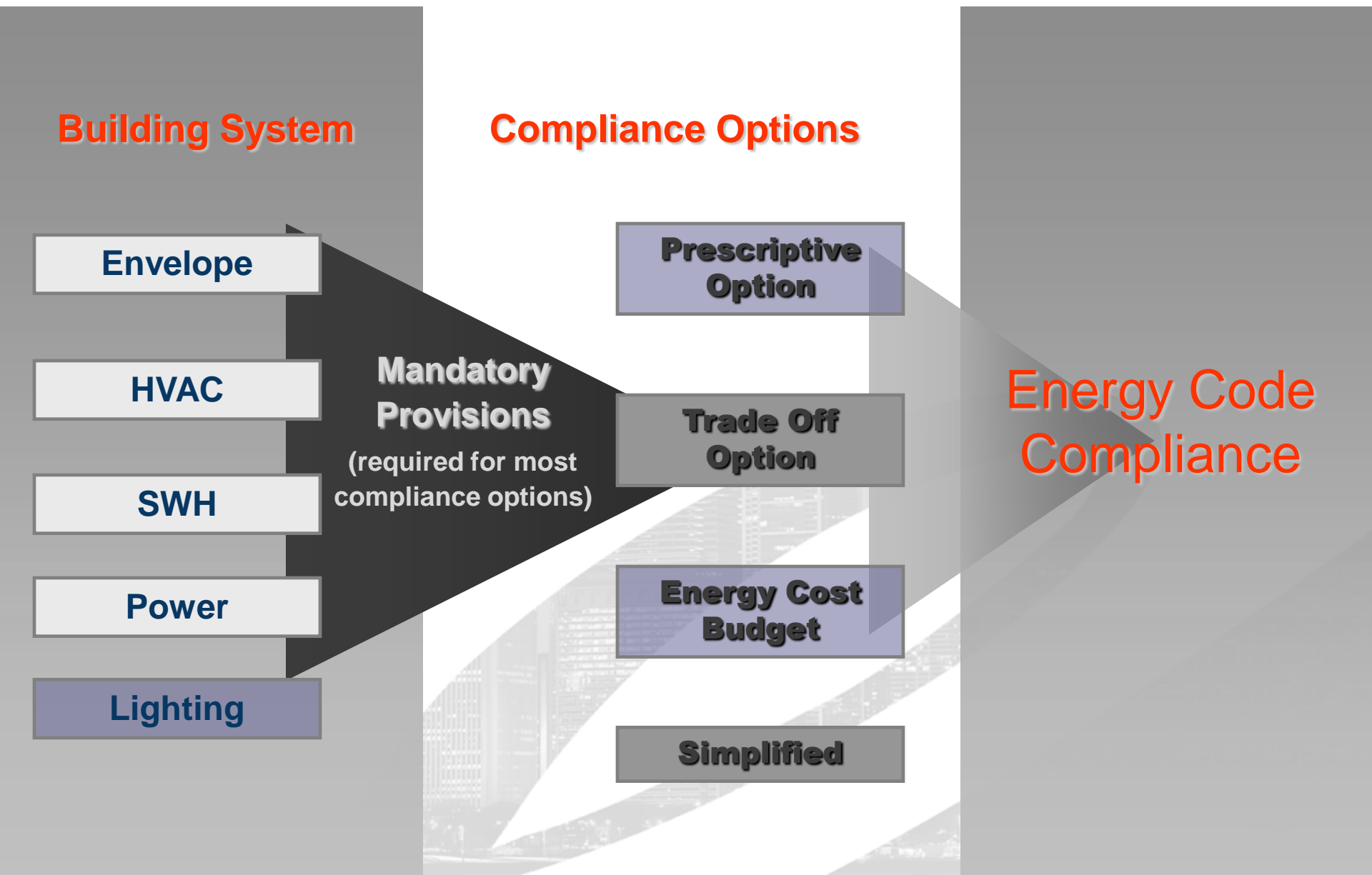
Prescriptive Option

Trade Off Option

Energy Cost Budget

Simplified

Energy Code Compliance



Lighting General

○ Scope

1. Interior spaces of buildings
2. Exterior building features
3. Exterior grounds lighting powered through building
4. Exceptions
 - Emergency lighting
 - Lighting required by life safety statute
 - Lighting within dwelling units of buildings
 - Decorative gas lighting

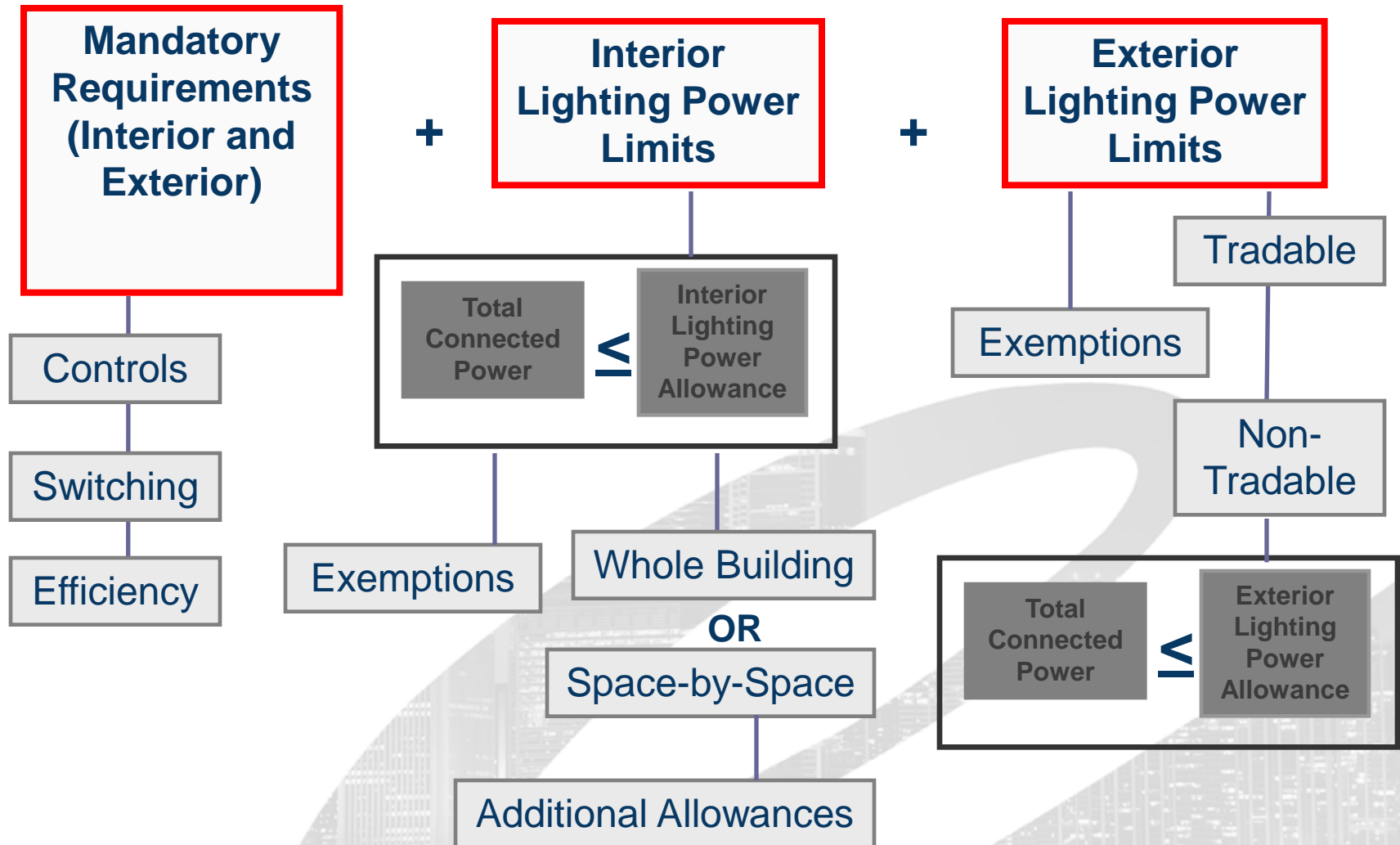


- ## ○ Lighting Alterations – New lighting and lighting controls must comply with this section, unless an alteration replaces less than 50% of luminaires in a space and that alteration does not increase the installed lighting power

Lighting General (cont.)

- Installed Interior Lighting Power shall include all power used by the luminaires, including lamps, ballasts, transformers, and controls
 1. **Exception:** in the case where there are two independently operated lighting systems that are controlled to prevent simultaneous operation
 - Include only the higher wattage system
- Luminaire Wattage for various systems shall determined in accordance with details in Section 9.1.4

Standard 90.1 Basic Lighting Requirements



Standard 90.1 - Lighting

- General Application (*Section 9.1*)
 1. Scope
 2. Lighting Alterations
 3. Installed Interior Lighting Power
 4. Luminaire Wattage
- Compliance Path(s) (*Section 9.2*)
- Mandatory Provisions (*Section 9.4*)
 1. Lighting control
 2. Tandem wiring
 3. Exit signs
 4. Exterior building grounds lighting
 5. Exterior building lighting power
- Building Area Method Compliance Path (*Section 9.5*)
- Alternative Compliance Path: Space-by-Space Method (*Section 9.6*)



When Do Lighting & Power Requirements Apply?

- Original Installed Lighting System in a New Building, Addition, or Tenant Build-out
- Existing Lighting System that is Altered
- Change in Occupancy that Increases Energy

Exceptions:

- *Historic buildings*
 1. *State or National listing*
 2. *Eligible to be listed*
- *Alterations where less than 50% of the luminaires are replaced and power is not increased*
- *Lighting within dwelling units*
 1. *Where $\geq 50\%$ of permanently installed fixtures are high-efficacy lamps*

High-Efficacy Lamps

- Defined in the 2009 IECC as:
 1. Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy based on lamp wattage

Lamp Wattage	Efficacy
> 40 watts	60 lumens/watt
15-40 watts	50 lumens/watt
< 15 watts	40 lumens/watt

Luminaire Wattage – Standard 90.1

- Standard incandescent = max. labeled wattage of the luminaire
- Luminaires with ballasts or transformers = wattage of the maximum lamp/ballast combination OR max. labeled wattage of the luminaire
- Line voltage track = actual wattage with a min. 30 W per foot OR wattage limit of system's circuit breaker OR wattage limit of other permanent-current-limiting device(s) on the system
- Low voltage track = transformer wattage
- All others as specified on equipment

Mandatory: Individual Space Control IECC and Standard 90.1

IECC

- Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area.
- The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status

Standard 90.1

- At least one for each room or space enclosed by ceiling-height partitions
 - in spaces $\leq 10,000 \text{ ft}^2$, each control serves 2500 ft^2 maximum and in spaces $> 10,000 \text{ ft}^2$, serves $10,000 \text{ ft}^2$ maximum
- Readily accessible to occupants
- Remote location is allowed to accommodate areas where safety or security is a concern

Mandatory: Additional Space Controls – IECC and Standard 90.1

- Hotel/motel guest room lighting must be controlled at room entry
- Additional control required for:
 - Display/accent lighting
 - Case lighting
 - Task lighting
 - Nonvisual lighting
 - Demonstration lighting
- Occupancy sensors are required in:
 - Classrooms (except shop, lab, K-12)
 - Conference/meeting rooms
 - Employee lunch/break rooms



Interior Lighting Control: Light Reduction

Light Reduction Controls must allow the occupant to reduce connected lighting

1. By at least 50%
2. In a reasonably uniform illumination pattern

Note: Alternate Standard
Standard 90.1-2007 does not
require Light Reduction
Control



Intent: Allow occupants to moderate light levels to save energy!

IECC Interior Lighting Control: Light Reduction Exemptions

Light Reduction Control **Not** required for the following:

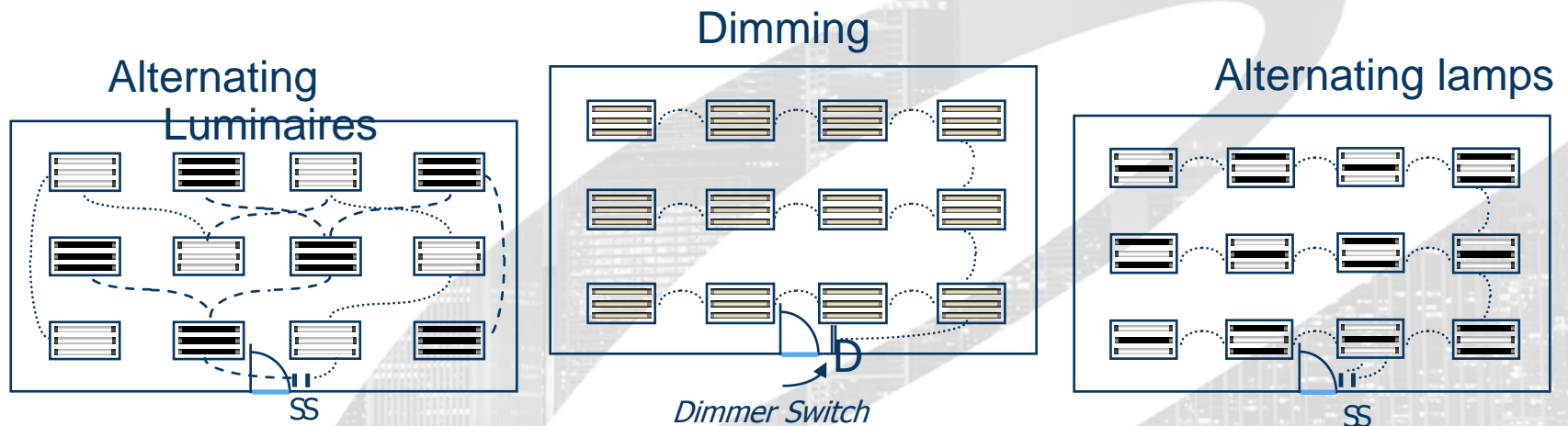
- Areas with only one luminaire
- Areas controlled by occupancy sensor
- Corridors, storerooms, restrooms or public lobbies
- Sleeping units
- Spaces with <0.6 w/ft²



Light Reduction Control Options

IECC

1. Controlling all lamps or luminaires
2. Dual switching of alternate rows of luminaires, alternate luminaires or lamps
3. Switching middle lamp luminaires independently from the outer lamps
4. Each luminaire or each lamp



Interior Lighting Control: Automatic Shutoff

Applies to both Codes

Automatic lighting shutoff control device required in all buildings larger than 5,000 ft²

Building Defined:

- “Any structure used or intended for supporting or sheltering any use or occupancy”
- Building area surrounded by exterior walls and fire walls

Exempted spaces:

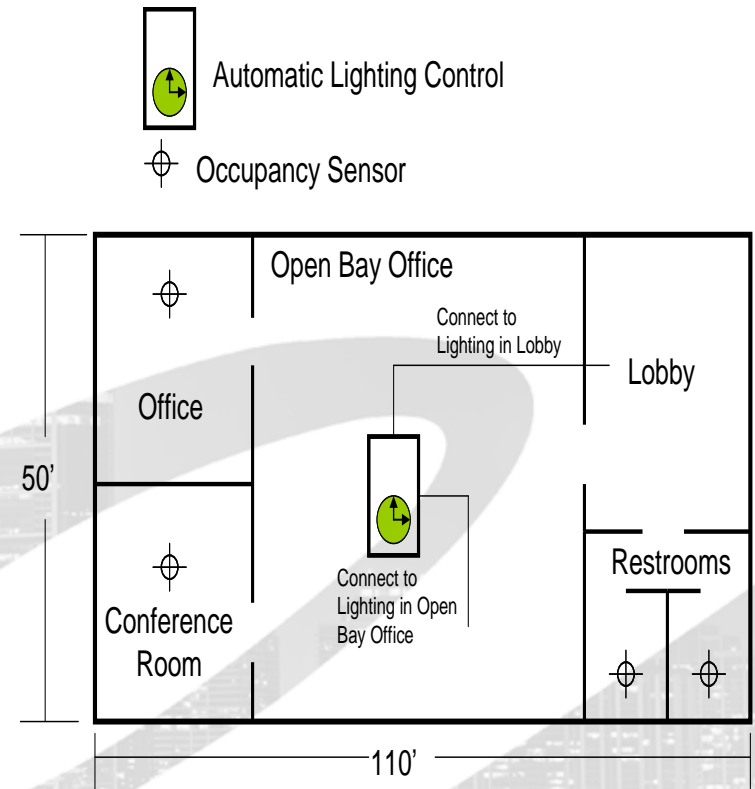
- Sleeping units
- Lighting for patient care
- When an automatic shutoff would endanger occupant safety or security

Intent: Eliminate after
hours lighting waste!

Standard 90.1 Interior Lighting Control: Automatic Shutoff Options

Automatic Lighting Shutoff Compliance Options

1. Control lights on a scheduled basis (automatic time switch)
 - Time-of-day controller
 - Controls $\leq 25,000$ ft² and not more than one floor, or
2. Occupant sensor
 - Turn lights off within 30 minutes of occupant leaving the space
3. Signal from another control or alarm that indicates the area is unoccupied



IECC Interior Lighting Control: Automatic Shutoff Override

- Readily accessible
- Within view of the lights or area controlled
- Manually operated
- ≤ 2 hour override
- Controls an area $\leq 5,000 \text{ ft}^2$
- Exemptions
 1. Can be over 2 hour override in malls and arcades, auditoriums, single-tenant retail space, industrial facilities and arenas when using captive key override
 2. Override in malls and arcades, auditoriums, single-tenant retail space, industrial facilities and arenas can cover up to $20,000 \text{ ft}^2$

IECC Interior Lighting Control: Holiday Scheduling

- Feature that turns off all loads for 24 hours then resumes the normally scheduled operation
- Exceptions:
 1. Retail stores and associated malls
 2. Restaurants
 3. Grocery stores
 4. Places of religious worship
 5. Theaters

Interior Lighting Power Limits IECC

Connected Interior Lighting Power must not exceed Interior Lighting Power Allowance

1. Calculate Interior Lighting Power Allowance
 - Building Area type allowance
 - Additional allowances
2. Calculate proposed connected lighting power
 - Wattage calculation “rules”
 - Exempted lighting
3. Compare values: proposed wattage must be less than or equal to allowed wattage



Intent: Eliminate waste from sloppy lighting design and application!

Office - Example

A 200,000 ft² office building that contains corridor, restrooms, break rooms and a lobby is given 1.0 W/ft² for the entire building

Table
505.5.2

Office: 200,000 ft²
1.0 W/ft² = 200,000 W

LIGHTING POWER DENSITY	
Building Area Type ^a	(W/ft ²)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare – clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail ^b	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

IECC Interior Lighting Power Allowance for Multiple Occupancy Building

How is an allowance determined if the building has more than one Building Area Type?

Example – A building contains the following area types

- Museum: 40,000 ft²
- Retail: 5,000 ft²
- Cafeteria: 10,000 ft²

- Use the more specific building area type where more than one area type exists in the building
- Sum the individual (lighting power density X area square footage) values for Total Power Allowance

Exit Signs IECC and Standard 90.1

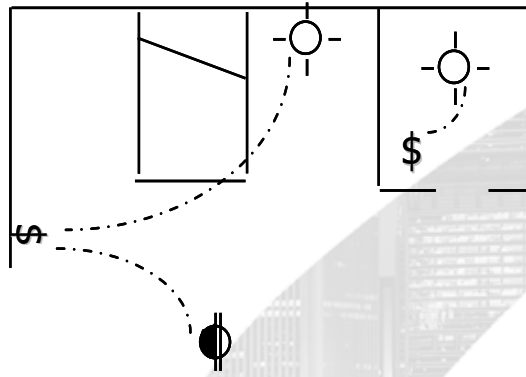
- Exit Signs
 1. Internally illuminated exit signs shall not exceed 5 watts per side



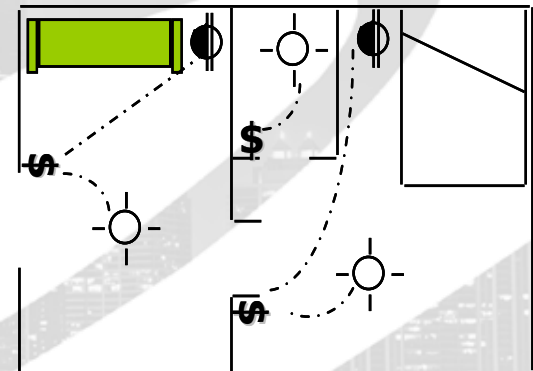
IECC Interior Lighting Control: Sleeping Unit Lighting Control

- Applies to hotels, motels, boarding houses, or similar
- Master switch required at each room or main room entry
- Must control all permanently wired luminaires or switched receptacles
 1. Exceptions: bathrooms

Intent: Allow occupant to turn off lights at exit point!



Standard Room



Suite

IECC Gross Lighted Area

- Sum of total lighted area of a building
 1. Measured from the exterior faces of the exterior walls or from the centerline of walls separating buildings, but excluding a long list of areas. (See Standard).
- Used in the building area method of determining interior lighting power allowance



IECC Additional Interior Lighting Power

- An increase in the ILPA is allowed for specific space functions when using the space-by-space method. Applications must be automatically controlled, separately from the general lighting, to be turned off during non-business hours
 1. Decorative in addition to general lighting – 1.0 W/ft^2 in space used
 2. Fluorescent designed to eliminate computer screen glare – 0.35 W/ft^2
 3. Retail display lighting



Standard 90.1 Retail Display Lighting

Additional Interior Lighting Power Allowance = 1000 watts +
(Retail Area 1 x 1.0 W/ft²) +
(Retail Area 2 x 1.7 W/ft²) +
(Retail Area 3 x 2.6 W/ft²) +
(Retail Area 4 x 4.2 W/ft²),

Where:

Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork.

Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.

Exception: Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

Building Area Method of Calculating Interior Lighting Power Allowance

- Used for projects involving
 1. An entire building
 2. A single, independent, and separate occupancy in a multi-occupancy building
- Gross lighted area is multiplied by allowance from Table 9.5.1
- Limitations
 1. Insensitive to specific space functions and room configurations
 2. Generally is more restrictive
 3. Does not apply to all building types - but “selection of a reasonably equivalent type” is permitted

IECC Proposed Lighting Calculation: Rules

Lighting wattage must be documented in accordance with Section 505.5.1

- Screw lamp holders: maximum labeled wattage of the luminaire
- Low voltage lighting: transformer wattage
- Line voltage track:
 1. specified wattage with minimum of 30 W/linear ft **OR**
 2. wattage limit of system's circuit breaker **OR**
 3. wattage limit of other permanent current limiting devices
- Other: manufacturer's rated wattage of lamp and associated ballast

IECC Proposed Lighting Power Calculation

- Sum the wattage of all proposed connected lighting power
- This must include all lighting that is part of the design for the space including:
 1. Overhead lighting
 2. Task lighting
 3. Decorative lighting
- Exceptions



Note: Wattage must be calculated based on actual power draw...not just nominal lamp rating

Daylight Zone Control Section IECC

Section 505.2.2.3

- Daylight zones
 - Must have individual control of the lights independent of general area lighting
- Contiguous daylight zones adjacent to vertical fenestration
 - Can be controlled by a single controlling device if the zone doesn't include areas facing more than two adjacent cardinal orientations (i.e., north, east, south, west)
- Daylight zones under skylights > 15 ft from the perimeter
 - Must be controlled separately from daylight zones adjacent to vertical fenestration
- Exception
 - Daylight spaces 1) enclosed by walls or ceiling height partitions and 2) containing two or fewer light fixtures -- not required to have a separate switch for general area lighting

Note: required controls may be manual or automatic

Daylighting

- Saves energy
- Reduces cooling load
- Improves occupant productivity
- Good daylighting design produces high quality, even illumination that reduces contrast, glare, and heat gain through proper shading and space planning



Daylighting Benefits

- Quality Illumination
- Reduce Glare



Basic Daylighting Design Strategies

N/S Orientation, Thin Plan, High, Sloped Ceilings, Light- Colored Reflective Finishes, Automatic controls, etc.

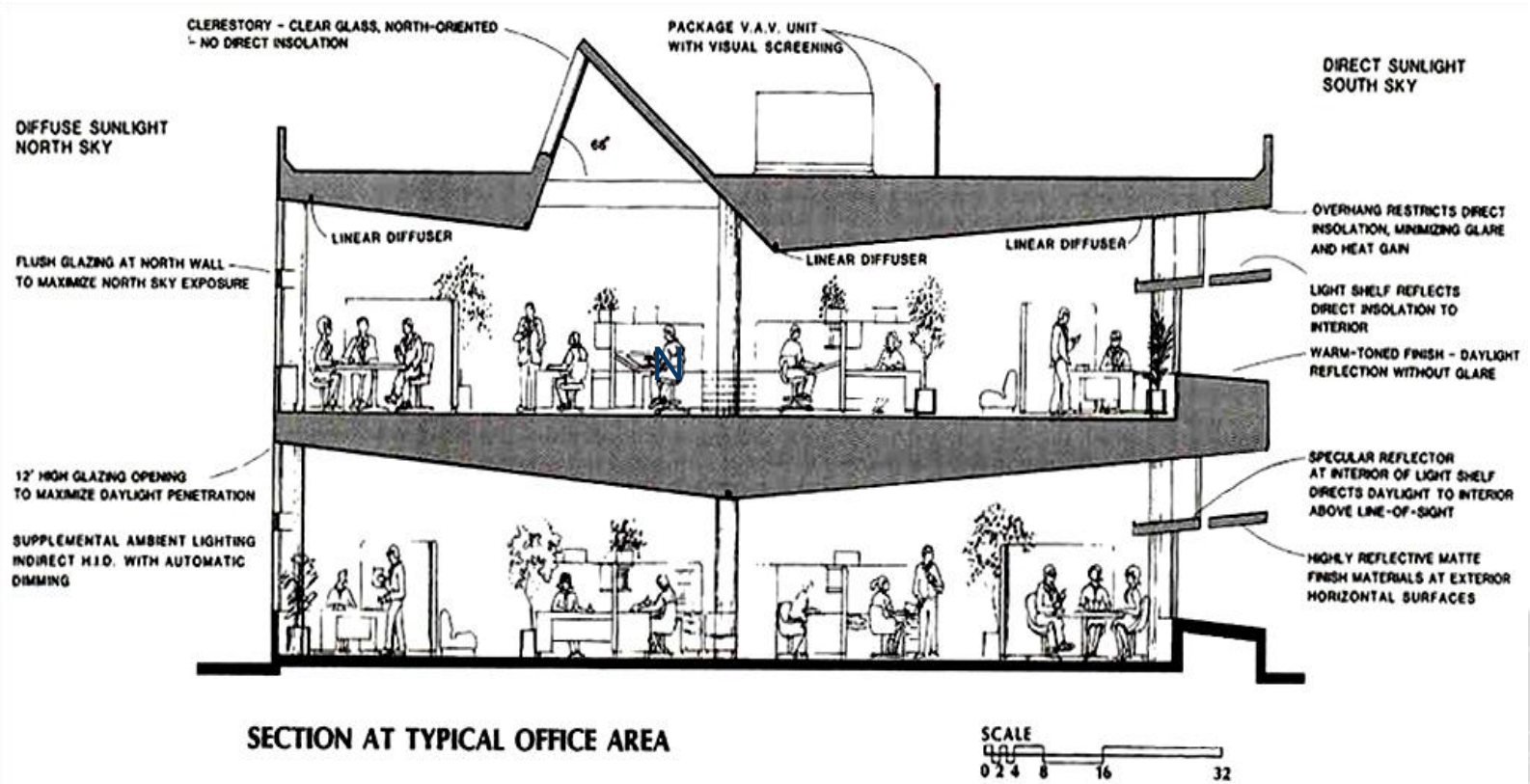
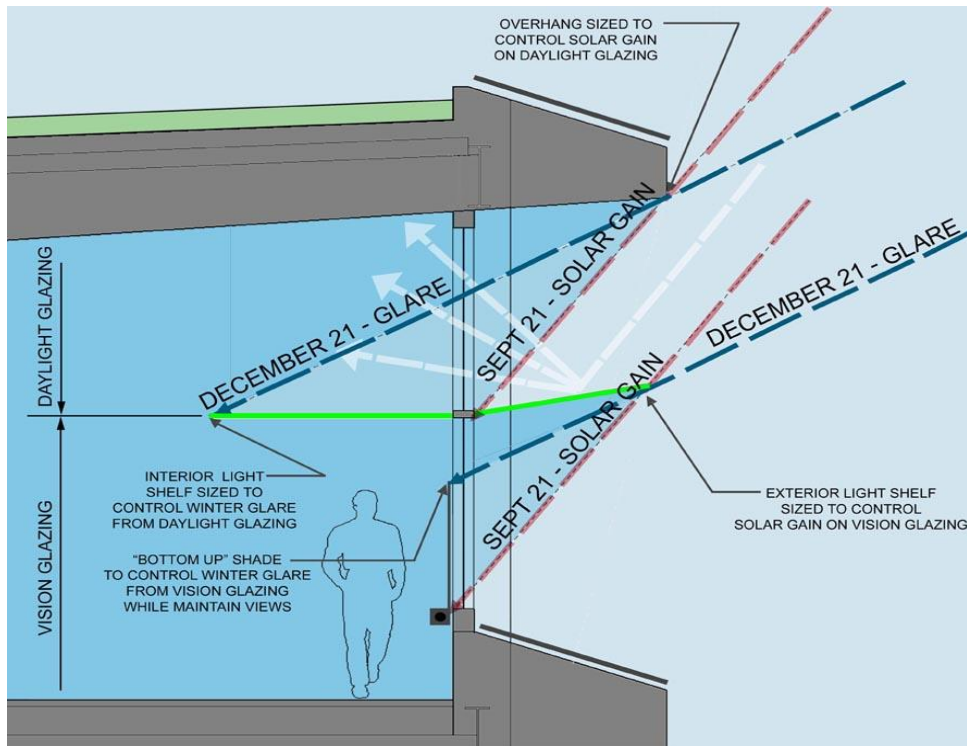
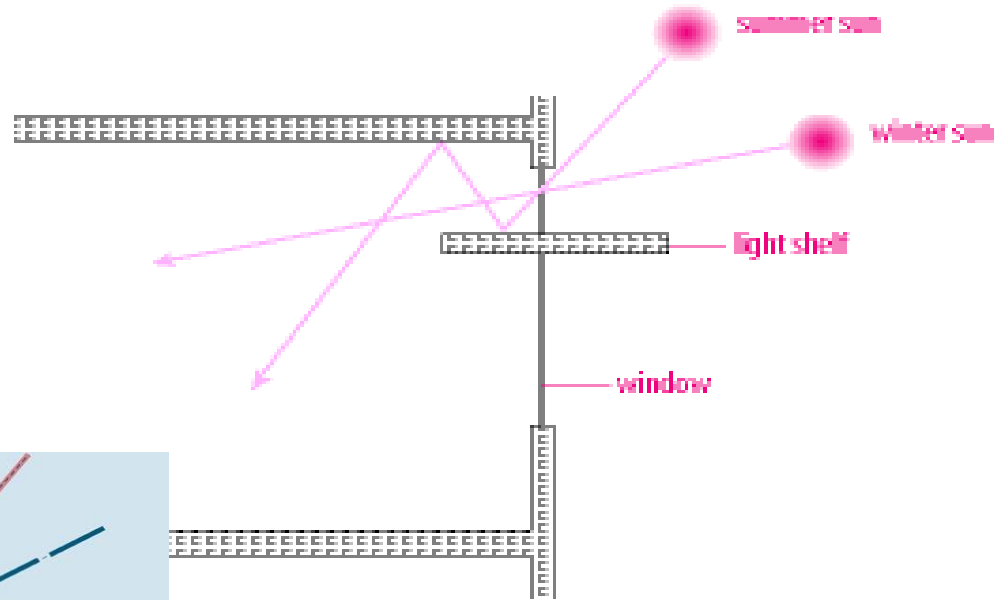


Figure 13.11f Light shelves, sloped ceilings, clerestories, north-facing windows, and open planning all help to illuminate the Ventura Coastal Building during the day. (Courtesy of and ©Mike Urbanek, 1211 Maricopa Highway, Ojai, CA 93023.)

Daylighting Design Elements

- **Light Shelves**

Transmit light while
Reducing summer solar
heat gain



Daylighting - Technologies

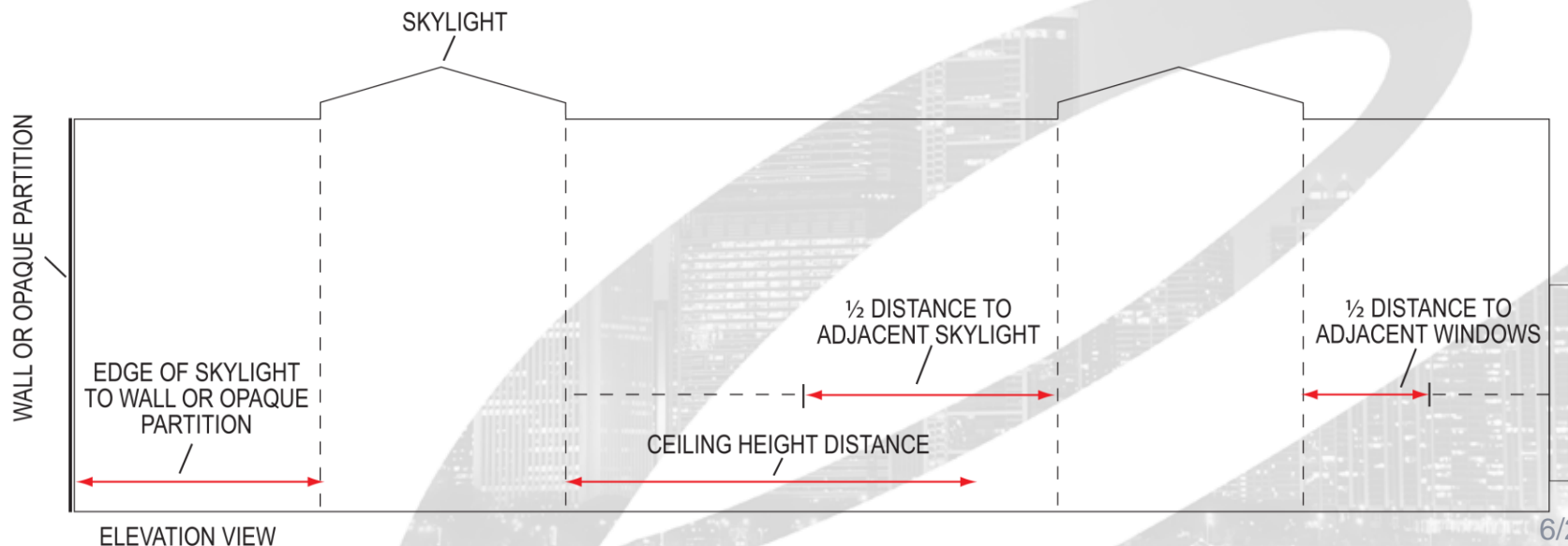
- Light Tubes: Transmit light while reducing heat gain
- Clerestories & Light Monitors: Simulate natural sunlight by illuminating the ceiling and brightening the interior of the building
- Exterior Shading: Prevents direct sunlight from entering
- Low-Transmittance Glass: Prevents glare
- Interior Shading / Blinds: Offer shading when necessary



Definition of Daylight Zone Under Skylights

The area under skylights whose horizontal dimension, in each direction, is equal to the skylight dimension plus the smaller of:

- The floor-to-ceiling height, or
- The distance to a ceiling height opaque partition, or
- One-half the distance to adjacent skylights or windows



Exterior Building Lighting Power – Standard 90.1

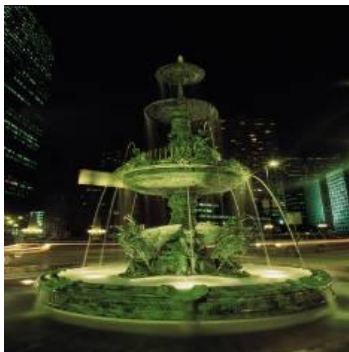
- The total exterior lighting power allowance is the sum of the individual lighting power densities [LPD]....
-plus an additional unrestricted allowance of 5% of that sum.
- Trade-offs are allowed only among “Tradable Surfaces” applications.
- Some exemptions apply

Exterior Building Lighting Power Standard 90.1

- Lighting used for the following exterior applications is exempt when equipped with a control device independent of the control of the nonexempt lighting:
 1. specialized signal, directional, and marker lighting associated with transportation;
 2. lighting that is integral to advertising signage or directional signage;
 3. lighting that is integral to equipment or instrumentation and is installed by its manufacturer;
 4. lighting for theatrical purposes, including performance, stage, film, and video production;
 5. lighting for athletic playing areas;
 6. temporary lighting;
 7. lighting for industrial production, material handling, transportation sites, and associated storage areas;
 8. theme elements in theme/amusement parks;
 9. lighting used to highlight features of public monuments and registered historic landmark structures or buildings.

Exterior Lighting Control Requirements IECC Table 505.2.4

- For dusk-to-dawn lighting: astronomical time switch or photo-sensor
- For all other: astronomical time switch OR photo-sensor + time switch
- All time switches must have 10 hour battery backup



Exterior Lighting Control Requirements

IECC

- Automatic lighting shutoff control device required in all buildings larger than 5,000 ft²
- Override of automatic shutoff required for not more than 4 hours
- Exceptions to automatic shutoff:
 - Lighting for 24-hour operation
 - Patient care spaces
 - Areas with safety or security concerns

Standard 90.1

- For dusk-to-dawn lighting: astronomical time switch or photo-sensor
- For all other: astronomical time switch **OR photo-sensor + time switch [REVISED!]**
- All time switches must have 10 hour battery backup
- Exceptions:
 1. Covered vehicle entrances
 2. Exits from buildings or parking structures
 3. (where required for safety, security, or eye adaptation)

Additional Control

- Many special lighting applications must be controlled separately
 1. Display/accent lighting
 2. Case lighting
 3. Hotel/motel guest room lighting
 4. Task lighting
 5. Nonvisual lighting
 6. Demonstration lighting

Exterior Efficiency Requirement IECC

Section 505.6.1

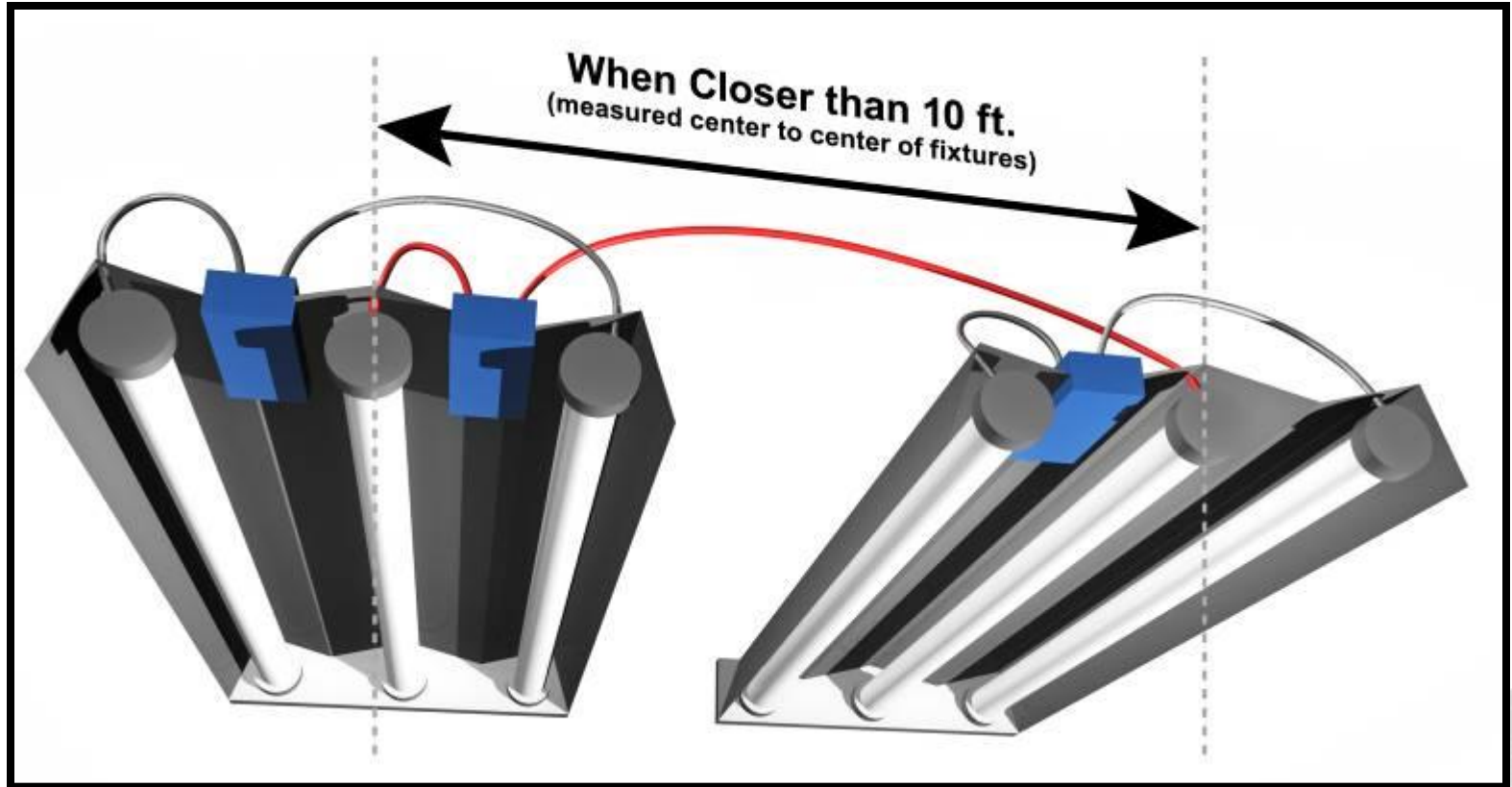
Building grounds lighting luminaires over 100 watts must have source efficacy of at least 60 lumens per watt

Light Source	Typical System Efficacy Range in LPW (varies depending on wattage and lamp type)
Incandescent	10-18
Halogen incandescent	15-20
Compact fluorescent (CFL)	35-60
Linear fluorescent	50-100
Metal halide	50-90

Exceptions:

- Controlled by motion sensor
- Any of the exterior lighting power allowance exceptions
- As approved for a historical, safety, signage, or emergency consideration

Tandem Wiring Standard 90.1



Eliminate use of single lamp, low-frequency ballast where possible

Tandem Wiring Exceptions Standard 90.1

- Separated surface or pendant luminaires
- Recessed luminaires more than 10 ft apart
- Other luminaires
 1. With three-lamp ballasts
 2. On emergency lighting circuits
 3. With no available pair
 4. With one lamp, high frequency, electronic ballast

Exterior Lighting Power IECC

- Building grounds lighting luminaires over 100 watts must have lamp efficacy of at least 60 lumen/Watt
- Exterior Building Lighting Power must meet prescribed wattage limits. Exterior applications divided into 2 categories:

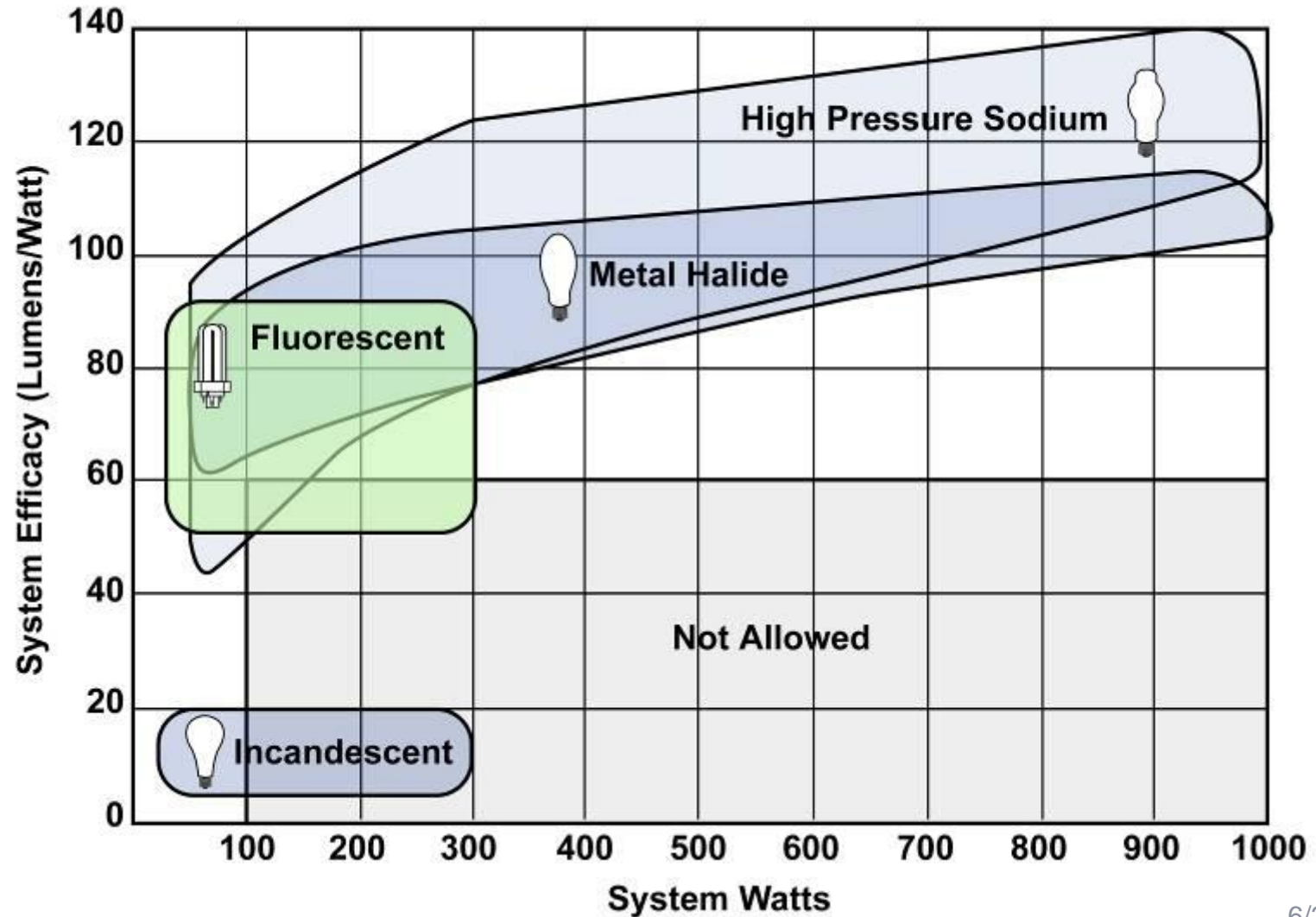
Tradable: allowed wattage may be traded among these applications

Non-Tradable: allowed wattage **cannot** be traded between surfaces or with other exterior lighting



Efficacy

Exterior Grounds Lighting and Specific Technologies



Exterior Lighting Exemptions

IECC

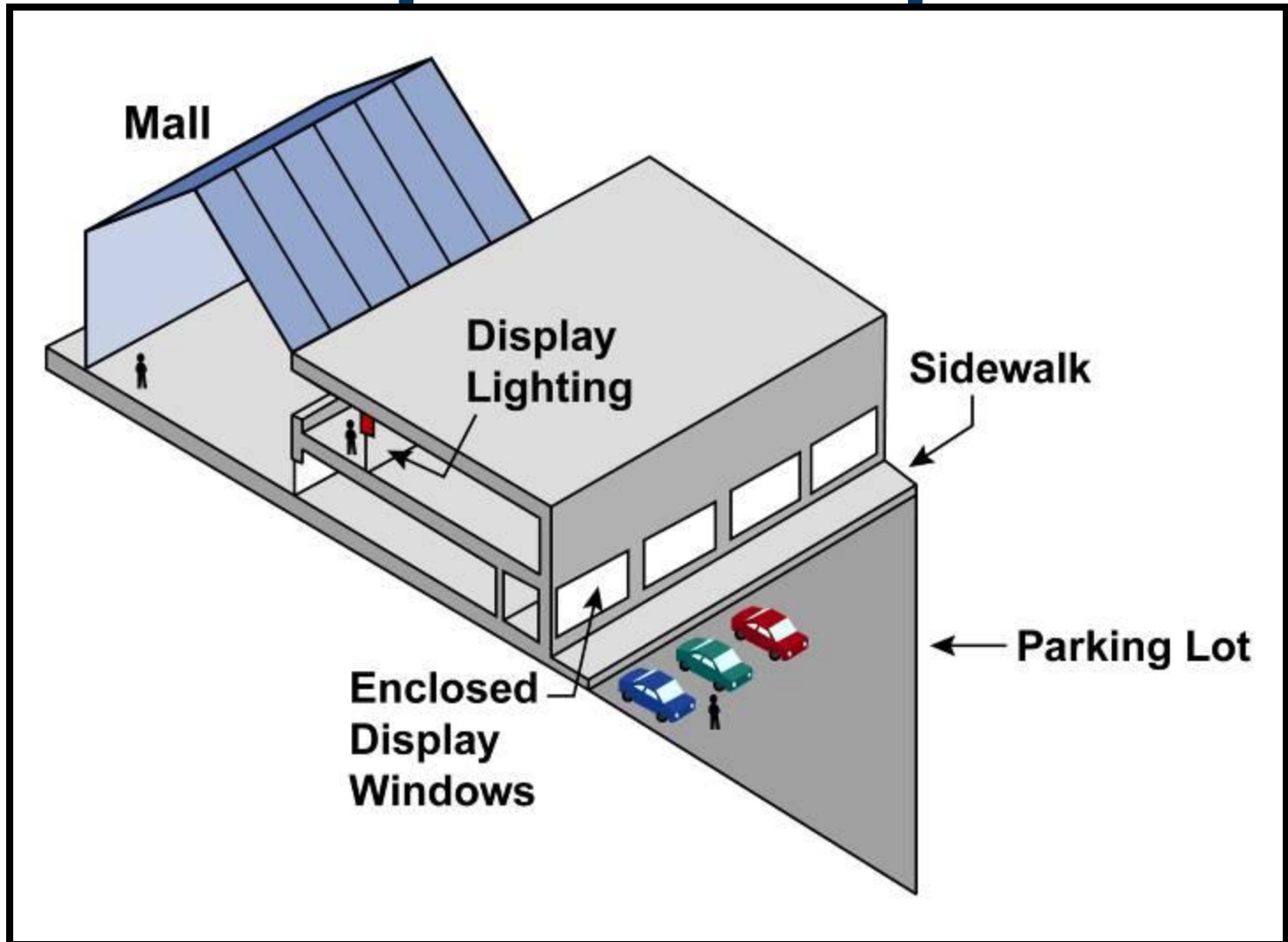
The following lighting does not need to be included in the proposed lighting calculation:

- Specialized signal, directional, and marker lighting associated with transportation
- Advertising signage or directional signage
- Lighting integral to *equipment* or instrumentation and installed by its *manufacturer*
- Lighting for athletic playing areas
- Theme elements in amusement parks
- And more...

Standard 90.1

- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Integral to equipment or instrumentation installed by manufacturer
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- And more...

Exemption Example



Exterior Lighting Power Limits IECC

505.6.2

Connected Exterior Lighting Power must not exceed Exterior Lighting Power Allowance

1. Calculate exterior Lighting Power Allowance
 - Lighting power densities by exterior function and by applicable lighting zone
2. Calculate proposed connected lighting power
 - Wattage calculation “rules”
 - Exempted lighting
3. Compare values: proposed wattage must be less than or equal to allowed wattage

Exterior Lighting Power Limits IECC

505.6.2

What areas are covered under exterior lighting allowances?

1. Tradable surfaces

Common exterior lighted needs that can be traded for other needs. For example, wattage allowed for parking lot lighting can be “traded” and used for canopy lighting.

1. Nontradable surfaces

Less common exterior lighted needs that **cannot** be traded for other needs. These applications have more specific security or task illuminance needs.



Tradable Surfaces

- Uncovered parking lots and areas
- Walkways (under and over 10 feet wide)
- Stairways
- Pedestrian tunnels
- Main building entrances
- Other doors
- Entry canopies
- Free-standing and attached sales canopies
- Open sales areas
- Street frontage sales areas



Nontradable Surfaces

- Building facades
- Automated teller machines and night depositories
- Entrances and gatehouse inspection stations at guarded facilities
- Loading areas for law enforcement, fire, ambulance and other emergency vehicles
- Drive-up windows/doors
- Parking near 24-hour retail entrances



Exterior Lighting Zones IECC Table

505.6.2(1)

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

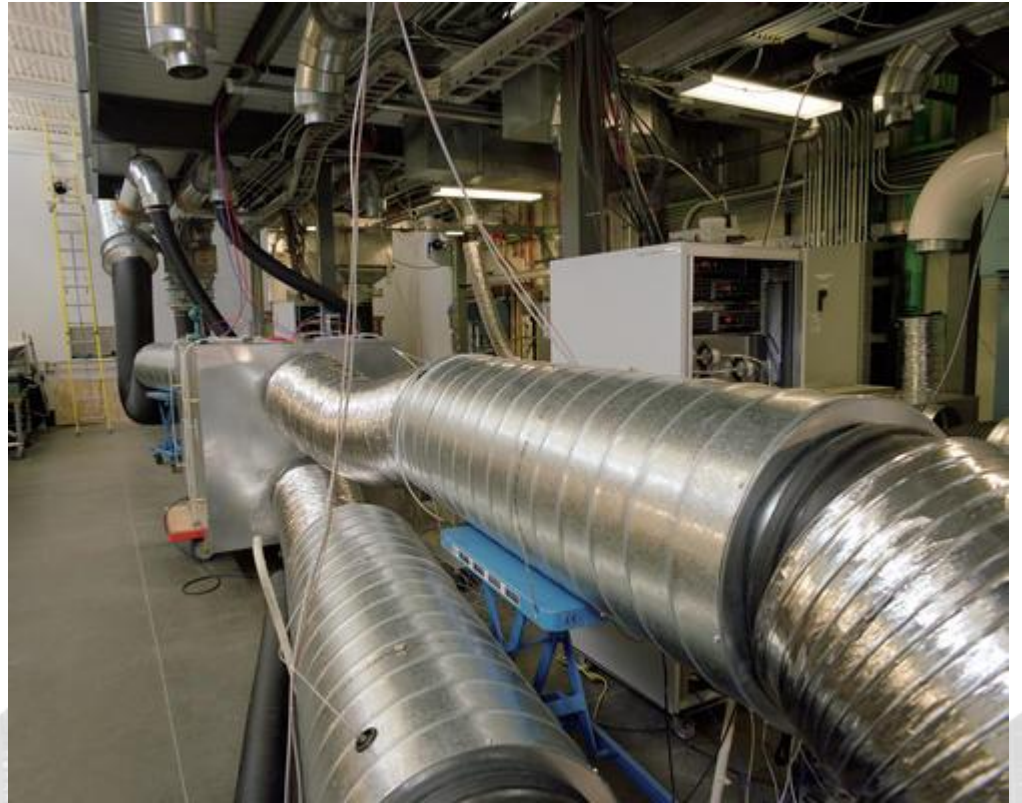
Electrical Energy Consumption Mandatory Requirement IECC 505.7

- Separate metering required for each dwelling unit

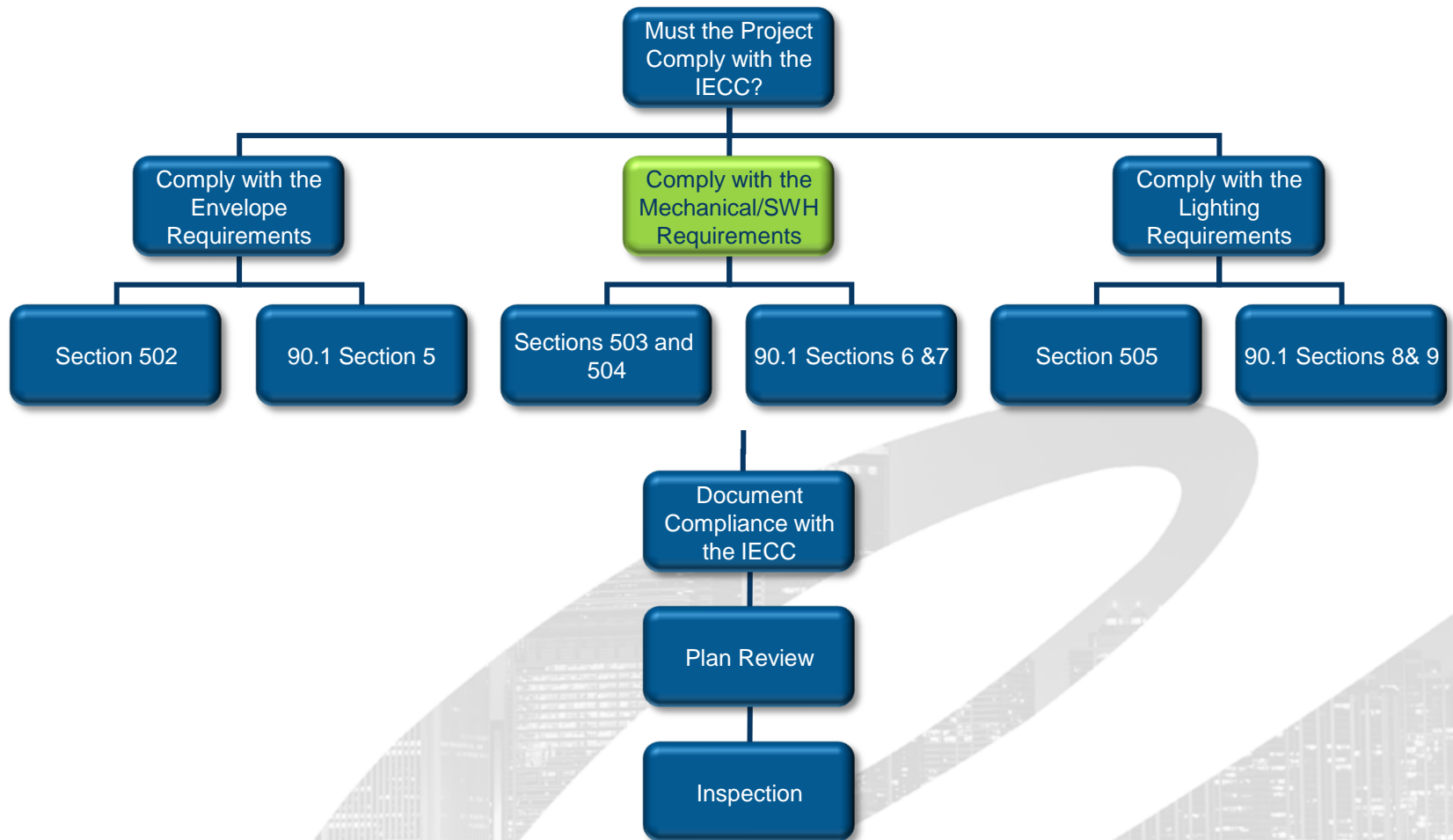


Intent: Occupant understanding of actual energy use can promote effective energy use!

HVAC



IECC: Commercial Energy Code Compliance



HVAC Compliance Standard 90.1

Building System

Envelope

HVAC

SWH

Power

Lighting

Other

Mandatory Provisions

(required for most compliance options)

Compliance Options

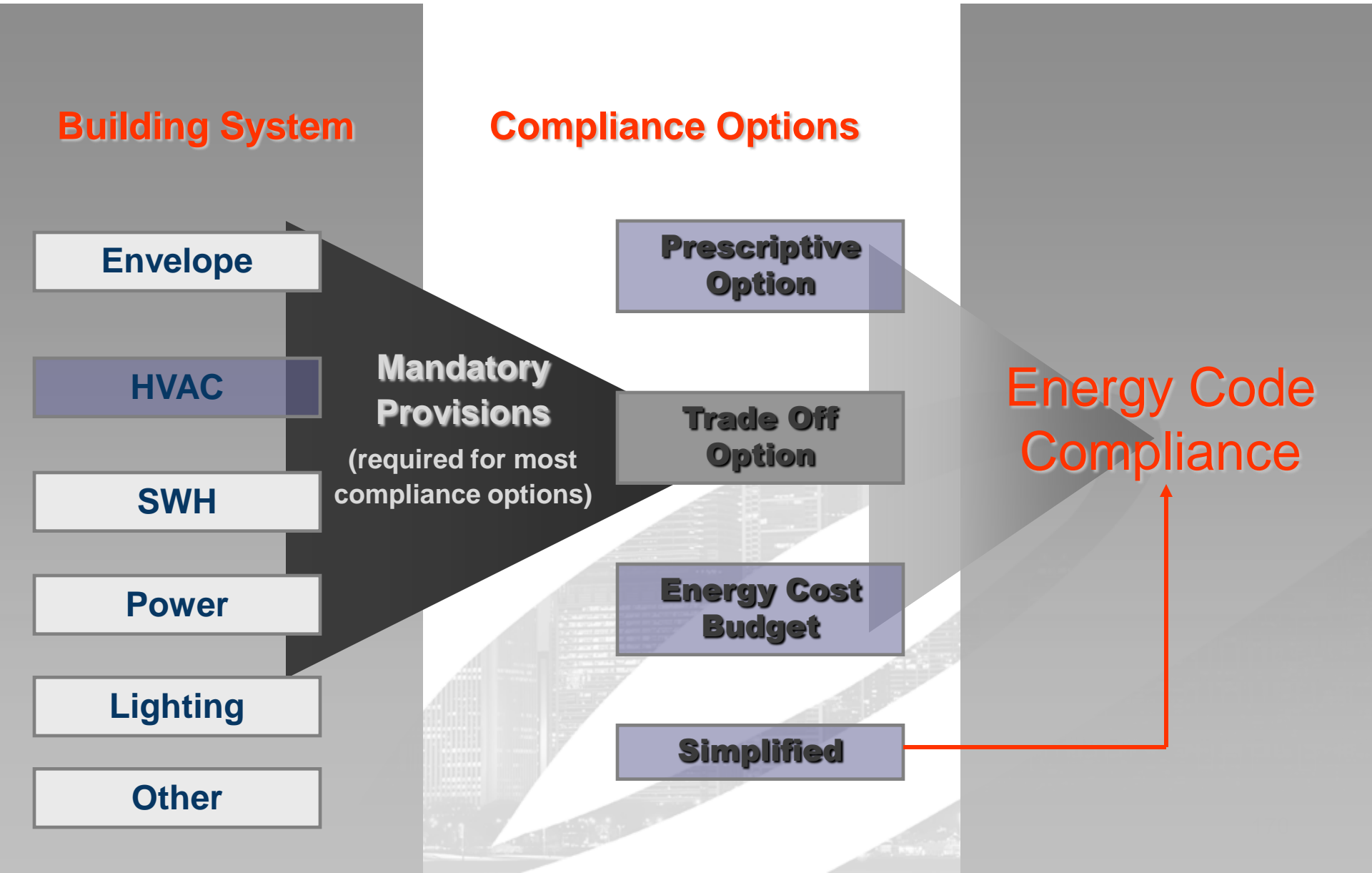
Prescriptive Option

Trade Off Option

Energy Cost Budget

Simplified

Energy Code Compliance



Mandatory Provisions IECC Section 503.2

Provisions Applicable to ALL Mechanical Systems

- HVAC Load Calculations
- Equipment and System Sizing
- HVAC Equipment Performance Requirements
- HVAC System Controls
- Ventilation
- Energy Recovery Ventilation Systems
- Duct and Plenum Insulation and Sealing
- Piping Insulation
- HVAC System Completion
- Air System Design and Control
- Motor Nameplate Horsepower
- Heating Outside a Building



IECC Section 503 Building Mechanical Systems

Simplified to Include Only Four Sections:

- What Provisions of the Code Apply (503.1)
- Mandatory Provisions (503.2)
- Simple HVAC Systems and Equipment (503.3)
- Complex HVAC Systems and Equipment (503.4)



HVAC Mandatory Provisions Standard 90.1

- Minimum Equipment Efficiency (*Section 6.4.1*)
- Load Calculations (*Section 6.4.2*)
- Controls (*Section 6.4.3*)
- HVAC System Construction and Insulation (*Section 6.4.4*)
- Completion Requirements (*Section 6.4.5*)

Simplified Approach Option

Standard 90.1

- Limited to...
 1. Buildings with 1 or 2 stories
 2. Buildings < 25,000 ft²
 3. Single-zone systems (unitary or split)
 4. Air-cooled or evaporatively cooled

90.1 Simplified Approach Option *(cont'd)*

- The system shall have an economizer, unless the economizer Trade-off Option is used
 - Limited to unitary systems
 - Requires higher minimum cooling efficiency (EER)
 - Trade-off EER by
 - System size
 - Climate zone

90.1 Simplified Approach Option *(cont'd)*

- Manual changeover or dual set-point thermostat
- Heat pump supplementary control
- No reheat or simultaneous heating and cooling for humidity control
- Time clocks (except hotel/motel guest rooms and systems requiring continuous operation)
- Piping and ductwork insulated

90.1 Simplified Approach Option *(cont'd)*

- Balancing of ducted systems
- Interlocked thermostats for separate heating and cooling
- Exhaust > 300 cfm: gravity or motorized dampers unless operated continuously
- System > 10,000 cfm: optimum start controls

HVAC Alterations – Standard 90.1

- Equipment - New equipment shall meet the minimum efficiency requirements
- Cooling systems
 1. New cooling systems installed to serve previously uncooled spaces shall comply with this section
 2. Alterations to existing cooling systems shall not decrease economizer capacity (unless economizer tradeoff is used)
- Ductwork - New and replacement ductwork shall comply with applicable requirements
- Piping - New and replacement piping shall comply with applicable requirements

HVAC Alterations – Standard 90.1

- Alterations to the building HVAC system shall comply with the requirements of Section 6

1. Exceptions that are allowed:

- Equipment being modified or repaired (not replaced)
 - provided such modifications will not result in an increase in the annual energy consumption
- Equipment being replaced or altered which requires extensive revisions to other systems and such replaced or altered equipment is a like-for-like replacement
- Refrigerant change of existing equipment
- Relocation of existing equipment
- Ducts and pipes where there is insufficient space or access to meet these requirements

Equipment Covered

- Package air conditioners and condensing units
- Heat pumps (air, water, and ground source)
- Packaged terminal and room air conditioners
- Chillers including absorption chillers
- Furnaces and unit heaters
- Boilers
- Heat rejection equipment



Mechanical Equipment Efficiency

- Tables 6.8.1A – 6.8.1G
- Tables 6.8.1H-6.8.1J used for water cooled centrifugal chillers that operate at non-standard rating conditions
- Combination HVAC and water heating systems to meet all requirements for appropriate space heating or cooling category
- Gas-fired and oil-fired forced air furnaces with input ratings $\geq 225,000$ Btu/h to have intermittent or interrupted ignition device and have either power venting or a flue damper
- All furnaces with input ratings $\geq 225,000$ Btu/h, including electric furnaces, not located in conditioned space, to have jacket losses $\leq 0.75\%$ of the input rating

Verification of Equipment Efficiencies

Equipment efficiency information from manufacturers verified as follows:

- EPACT equipment – to comply with DOE certification requirements
- If certification program exists for covered product and includes provisions for verification and challenge of equipment efficiency ratings, product listed in program OR
- If product not listed in program, ratings verified by an independent laboratory test report OR
- If no certification program exists, equipment efficiency ratings supported by data furnished by manufacturer OR
- Where components from different manufacturers are used, system designer specifies components whose combined efficiency meets Section .4.1
- Products in Table 6.8.1G shall have efficiency ratings supported by data furnished by manufacturer.

HVAC Performance (Minimum Efficiency) Requirements IECC Table 503.2.3

- Applies to all equipment used in heating and cooling of buildings
- Must comply with all listed efficiencies
- Exception
 1. Water-cooled centrifugal water-chilling packages

IECC Simple Versus Complex Systems

Simple systems

1. Unitary or packaged HVAC equipment
2. Serves one zone and controlled by a single thermostat

Section 503.3 Simple Systems

Buildings served by unitary or packaged HVAC each serving 1 zone controlled by 1 thermostat. Two-pipe heating systems serving multiple zones are included if no cooling system is installed [Tables 503.2.3(1) through 503.2.3(5)]

IECC Simple Versus Complex Systems

Complex systems

- All equipment not covered under Section 503.3 Simple Systems

[Section 503.4](#)
Complex
Systems

All buildings served
by HVAC systems not
covered under 503.3

HVAC Load Calculations *Both Codes*

Heating and cooling load sizing calculations required

- Standard 183
- Other approved computation procedures – defined in Chapter 3
 - Exterior design conditions
 - Specified by Standard 90.1
 - Interior design conditions
 - Specified by Section 302 of the IECC
 - $\leq 72^{\circ}\text{F}$ for heating load
 - $\geq 75^{\circ}\text{F}$ for cooling load

High Pressure Duct Systems

- Ducts designed to operate at static pressures \geq 3 in. w.g. to be leak-tested in accordance with SMACNA HVAC Air Duct Leakage Test Manual
- Air leakage rate < 6.0
- Must test $\geq 25\%$ of the duct area and meet the requirements

HVAC System Completion *IECC*

- Air System Balancing
- Hydronic System Balancing
- Manuals
 1. Equipment Capacity and Required Maintenance
 2. Equipment O & M Manuals
 3. HVAC System Control Maintenance and Calibration Information
 4. Written Narrative of Each System Operation

Simple HVAC Systems and Equipment *IECC*

Unitary or packaged, single zone controlled by a single thermostat in the zone served. Includes:

Simple Systems

- Unitary packaged cooling system
- Split system cooling
- Packaged terminal A/C
- Heat pump cooling
- Unitary packaged heating
- Split system heating
- Packaged terminal heat pump
- Fuel-fired furnace
- Electrical resistance heating
- Two-pipe heating systems w/o cooling
- Economizers

Complex HVAC Systems and Equipment *IECC*

Complex Systems

- Packaged VAV reheat
- Built-up VAV reheat
- Built-up single-fan, dual-duct VAV
- Built-up or packaged dual-fan, dual-duct VAV
- Four-pipe fan coil system with central plant
- Hydronic heat pump with central plant
- Any other multiple-zone system
- Hydronic space heating system
- Economizers

This section applies to all HVAC equipment and systems not included in Section 503.3

Load Calculations

- Must calculate heating and cooling system design loads
- Must base calculations on generally accepted engineering standards and handbooks



Equipment and System Sizing IECC

Output capacity SHALL NOT exceed sizing.

Select the system which serves the greater load, heating or cooling.

Exceptions:

- Standby Equipment with Required Controls
- Multiple Units with Combined Capacities Exceeding Load -- Sequencing Controls Required



HVAC System Construction and Insulation – Standard 90.1

- Insulation installed in accordance with industry-accepted standards
- Insulation protection
- Duct and plenum insulation
- Piping insulation
- Duct sealing
- Duct leakage tests



Duct Insulation and Construction



General

Insulation installed in accordance with industry-accepted standards

1. Protected from damage due to sunlight, moisture, equipment maintenance, and wind. Exposed to weather is suitable for outdoor service.
2. Covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space, to include a vapor retardant located outside the insulation, all penetrations and joints of which to be sealed.

Standard 90.1 Duct and Plenum Insulation

All supply and return ducts and plenums to be insulated per Tables 6.8.2A and 6.8.2B

Exceptions

1. Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
2. Ducts located in heated, semi-heated, or cooled spaces
3. For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
4. Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft² need not exceed R-2; those ≤ 5 ft² need not be insulated



Standard 90.1 Duct Sealing

Table 6.4.4.2A

- Requirements of 6.4.4.2
- Based on standard industry practice and definitions

Table 6.4.4.2A Minimum Duct Seal Level				
Duct Location	Duct Type			
	Supply		Exhaust	Return
	≤2 in. w.c. [†]	>2 in. w.c. [†]		
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces ^{**}	C	B	B	C

* See Table 6.4.4.2B definition of Seal Level.
† Duct design static pressure classification.
** Includes indirectly conditioned spaces such as return air plenums.

Duct Leakage Tests Applies to Both Codes

- Designed > 3 in. w.c.
 1. Leak tested
 2. Representative sections $\geq 25\%$ of the total installed duct area shall be tested
 3. Ratings > 3 in. w.c. to be identified on drawings
 4. Maximum permitted duct leakage

$$L_{\max} = C_L P^{0.65}$$

Where L_{\max} = maximum permitted leakage in cfm/100 ft² duct surface area

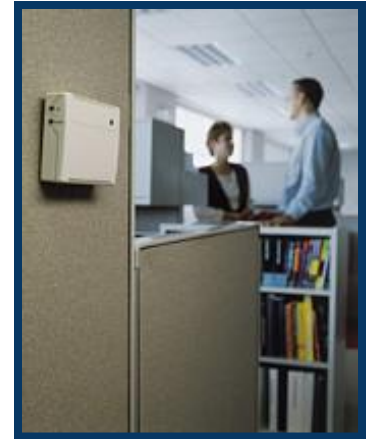


HVAC Temperature Control



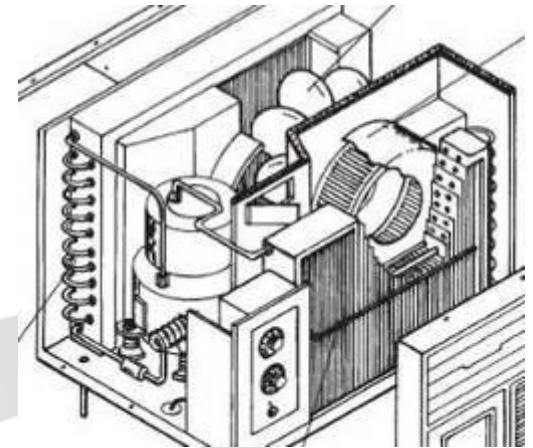
Standard 90.1 Controls – Zone Thermostatic and Dead Band

- Required for each zone
 1. Perimeter can be treated differently
- Dead band controls
 1. Thermostats must have at least a 5°F dead band
 2. Exceptions
 - Thermostats that require manual changeover between heating and cooling modes
 - Special occupancy or applications where wide temperature ranges aren't acceptable (e.g., retirement homes) and approved by adopting authority



Zone Controls IECC

- Capable of operating in sequence the supply of heating and cooling energy to the zone
- Controls prevent
 1. Reheating
 2. Recooling
 3. Mixing or simultaneously supplying air previously heated or cooled
 4. Other simultaneous operation of heating and cooling systems to the same zone



System Controls *IECC*

One temperature and humidity (when applicable) controller per zone



Heat pump systems

- Heat pump thermostat required



Standard 90.1 Controls – Setpoint Overlap Restriction

- If limit switches, mechanical stops, or software programming for DDC systems are used, means will be provided to prevent the heating setpoint from exceeding the cooling setpoint minus any applicable proportional band

Controls – Off-Hour Standard 90.1

- Automatic shutdown
- Setback controls
- Optimum start
- Zone isolation
- Exceptions, HVAC systems
 1. with heating/cooling capacity < 15,000 Btu/h
 2. intended to operate continuously

Controls - Automatic Shutdown Standard 90.1

- Automatic 7-day/week time clock with 10-hour battery backup
 1. Exception: 2-day/week thermostat for residential applications
- Each control to have
 1. Occupant sensor, **OR**
 2. Manually-operated timer with maximum two hour duration, **OR**
 3. Security system interlock
- Exception: Residential occupancies allowed to operate with only 2 different time schedules/wk

Controls - Setback

- Climate Zones 2-8
 - Lower heating setpoint to 55°F or less
- Climate Zones 1b, 2b, 3b (hot/dry)
 - Automatically restart, temporarily operate
 - Raise cooling setpoint to 90°F or higher **OR**
 - Prevent high space humidity levels

Controls – Off-Hour Standard 90.1 and IECC

- Automatic shutdown
- Setback controls
- Optimum start
- Zone isolation
- Exceptions, HVAC systems
 1. with heating/cooling capacity < 15,000 Btu/h
 2. intended to operate continuously

Controls - Automatic Shutdown IECC and Standard 90.1

- Automatic 7-day/week time clock with 10-hour battery backup
 1. Exception: 2-day/week thermostat for residential applications
- Each control to have
 1. Occupant sensor, **OR**
 2. Manually-operated timer with maximum two hour duration, **OR**
 3. Security system interlock
- Exception: Residential occupancies allowed to operate with only 2 different time schedules/wk

Standard 90.1 Controls - Optimum Start

- Individual heating and cooling air distribution systems with
 1. Total design supply air capacity > 10,000 cfm
 2. Served by one or more supply fans
- Control algorithm to at least be a function of difference between space temperature and occupied setpoint and amount of time prior to scheduled occupancy



Controls - Zone Isolation

- Applies to
 1. Each floor in a multistory building
 2. Maximum 25,000 ft² zone on one floor
- Requirements
 1. Isolation devices to shut off outdoor and exhaust airflow when > 5,000 cfm
 2. Central systems shall be capable of stable operation with one isolation zone
 3. Capable of separate time schedules for each isolation zone

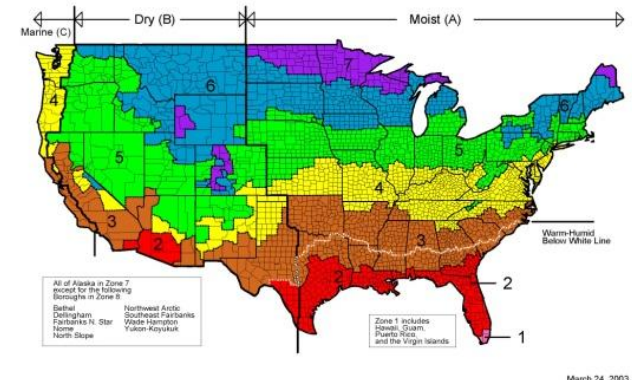
Stair and Shaft Vents IECC

- Motorized dampers
 1. Can be automatically closed during normal building operation
 2. Interlocked to open as required by fire and smoke detection systems



IECC Gravity Hoods, Vents, and Ventilators

- Motorized dampers to automatically shut when spaces served are not in use
- Exceptions
 1. Gravity dampers okay in buildings
 - < 3 stories in height above grade
 - Of any height in climate zones 1 - 3
 2. Ventilation systems serving unconditioned spaces



IECC Controls - Shutoff Damper

- Motorized dampers for outdoor air supply and exhaust systems
- Ventilation outside air dampers to be capable of automatically shutting off during preoccupancy building warm up, cool down, and setback

(Except when ventilation reduces energy costs or when ventilation must be supplied to meet code requirements)

Standard 90.1 Controls - Shutoff Damper

Exceptions:

1. Gravity dampers okay in buildings
 - < 3 stories in height
 - Of any height in climate zones 1-3
2. Outdoor-air intake or exhaust < 300 cfm

Table 6.4.3.3.4 provides maximum leakage rates for outdoor air supply and exhaust dampers

Standard 90.1 Dampers

Where OA supply and exhaust air dampers are required by Section 6.4.3.4:

They shall have a maximum leakage rate when tested in accordance with AMCA Standard 500 as indicated in Table 6.4.3.4.4

Standard 90.1 Ventilation Fan Controls

- Fans with motors > 0.75 hp shall have automatic controls complying with Section 6.4.3.3.1 that are capable of shutting off fans when not required
- Exception: HVAC systems intended to operate continuously

Standard 90.1 Heat Pump Auxiliary Heat Control

- Controls to prevent supplementary heat when heat pump can handle the load
- Exception: Heat pumps
 - With minimum efficiency regulated by NAECA
 - With HSPF rating meeting Table 6.8.1B(Includes all usage of internal electric resistance heating)



Standard 90.1 Controls - Humidification and Dehumidification

- Provide means to prevent simultaneous operation of humidification and dehumidification equipment:
Limit switches, mechanical stops, or software programming (DDC systems)
- Exceptions
 1. Zones served by desiccant systems, used with direct evaporative cooling in series
 2. Systems serving zones where specific humidity levels are required and approved by jurisdiction
 - Museums and hospitals

Standard 90.1 Ventilation Controls for High-Occupancy Areas

DCV must be provided for each zone with a area $> 500 \text{ ft}^2$ and the design occupancy > 40 people/1000 ft^2 where the HVAC system has:

1. An air-side economizer,
2. Automatic modulating control of the OSA dampers, or
3. A design outdoor airflow $> 3,000 \text{ cfm}$

Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

Standard 90.1 Ventilation: High Occupancy Exceptions

- Exceptions:
 - Systems with exhaust-air energy recovery complying with Section 6.5.6.1
 - Multiple zone systems without DDC to the zone level
 - Systems with a design OA airflow $<1,200$ cfm
 - Spaces where supply-exhaust $<1,200$ cfm

Demand Controlled Ventilation *IECC*

DCV must be provided for each zone with spaces $> 500 \text{ ft}^2$ and the average occupant load $> 40 \text{ people}/1000 \text{ ft}^2$ of floor area where the HVAC system has:

1. An air-side economizer,
2. Automatic modulating control of the outdoor air damper, or
3. A design outdoor airflow $> 3,000 \text{ cfm}$

Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

Demand Controlled Ventilation

IECC- Exceptions

- Systems with energy recovery per 503.2.6
- Multiple zone systems without direct digital control of single zones communicating with central control panel
- Systems with design outdoor airflow $< 1,200$ cfm
- Spaces where supply airflow rate minus any makeup or outgoing transfer air requirement $< 1,200$ cfm

Energy Recovery Ventilation Systems *IECC*

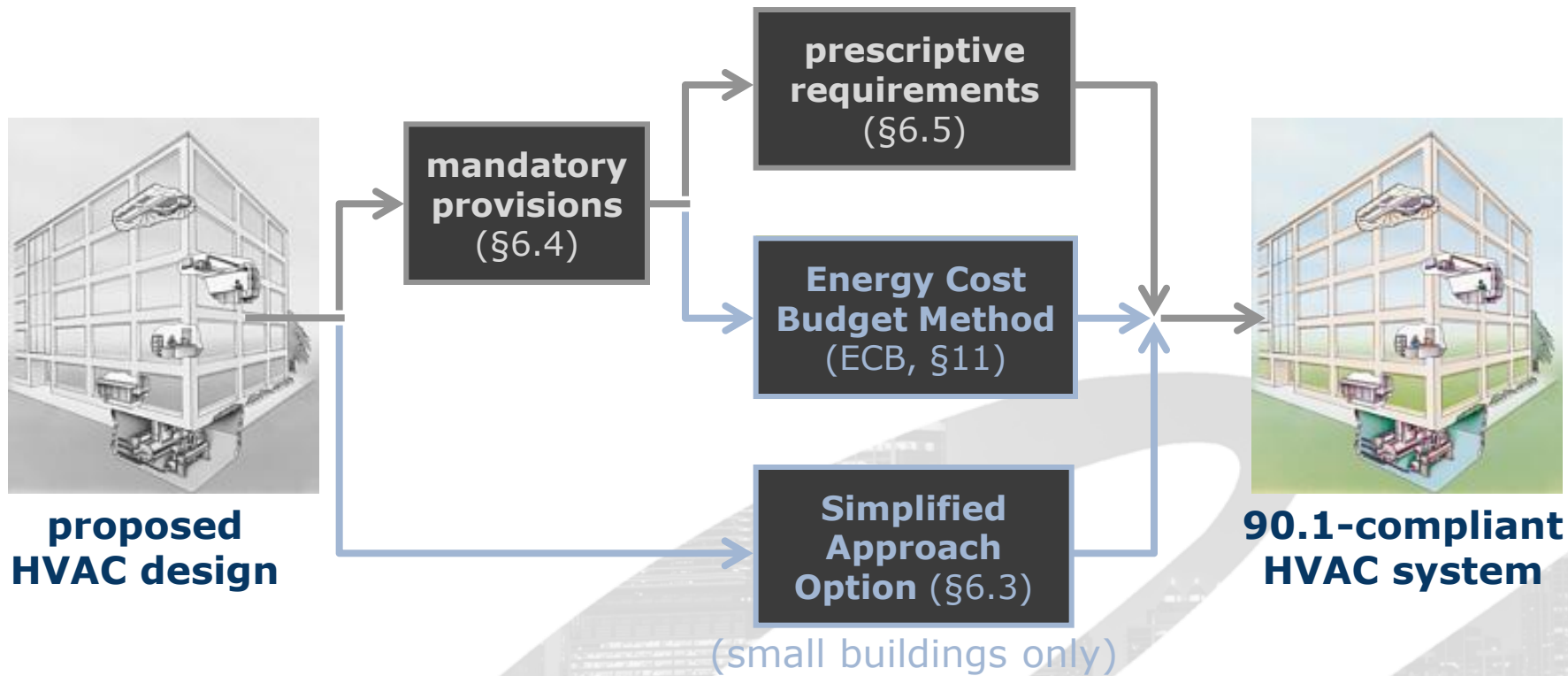
- Applies to individual fan systems with
 1. Design supply air capacity $\geq 5,000$ cfm
 2. Minimum outside air supply of $\geq 70\%$ of design supply air quantity
- Exhaust air recovery efficiency must be $\geq 50\%$

Exceptions: many

Energy Recovery Ventilation Systems *IECC - Exceptions*

- Where energy recovery ventilation systems prohibited by the IMC
- Lab fume hood system with at least one of the following:
 1. VAV hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to $\leq 50\%$ of design values
 2. Direct makeup (auxiliary) air supply equal to at least 75% of exhaust rate, heated no warmer than 2°F below room setpoint, cooled to no cooler than 3°F above room setpoint, no humidification added, and no simultaneous heating and cooling use for dehumidification control
- Systems serving uncooled spaces and heated to $< 60^{\circ}\text{F}$
- Where $> 60\%$ of outdoor heating energy is from site-recovered or site solar energy
- Heating systems in climates $< 4,720$ HDD (Baltimore)
- Cooling systems in climates with a 1% cooling design wet-bulb temperature $< 64^{\circ}\text{F}$
- Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil

Standard 90.1 Prescriptive Requirements



Standard 90.1 HVAC Prescriptive Path

- Economizers (*Section 6.5.1*)
- Simultaneous Heating and Cooling Limitation (*Section 6.5.2*)
- Air System Design and Control (*Section 6.5.3*)
- Hydronic System Design and Control (*Section 6.5.4*)
- Heat Rejection Equipment (*Section 6.5.5*)
- Energy Recovery (*Section 6.5.6*)
- Exhaust Hoods (*Section 6.5.7*)
- Radiant Heating Systems (*Section 6.5.8*)
- Hot Gas Bypass Limitation (*Section 6.5.9*)

Allowable Fan Floor Horsepower

- Each HVAC system at fan design conditions to not exceed allowable fan system motor nameplate hp (Option 1) or fan system bhp (Options 2) in Table 503.2.10.1(1)
- Exceptions
 1. Hospital and laboratory systems using flow control devices on exhaust and/or return for health and safety or environmental control permitted to use variable fan power limitation
 2. Individual exhaust fans ≤ 1 hp
 3. Fans exhausting air from fume hoods

Motor Nameplate Horsepower

- Selected fan motor to be no larger than first available motor size greater than bhp
- Note Fan bhp on design documents
- Exceptions
 1. Fans < 6 bhp, where first available motor larger than bhp has nameplate rating within 50% of bhp, next larger nameplate motor size may be selected
 2. Fans ≥ 6 bhp, where first available motor larger than bhp has nameplate rating within 30% of bhp, next larger nameplate motor size may be selected

Heating Outside a Building IECC

Section 503.2.11

- To be radiant systems
- Controlled by an occupancy sensing device or timer switch
 1. So system is automatically deenergized when no occupants are present

Economizers IECC 503.3.1

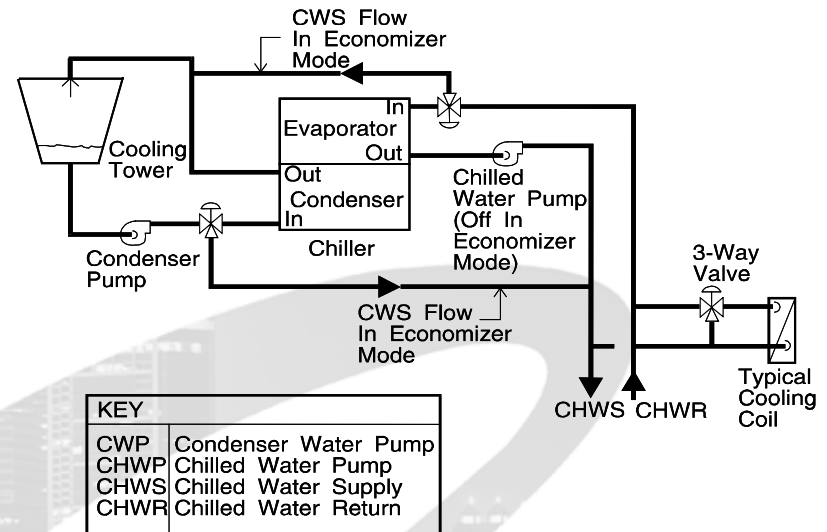
Table 503.3.1(1)

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C , 5A, 5B, 5C, 6A, 6B	Economizers on cooling systems $\geq 54,000$ Btu/h ^a

^a The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater

Economizers IECC Section 503.4.1

- Air side economizer requirements and equipment performance exceptions in Section 503.3.1(1) and 503.3.1(2)
- Water side economizer requirements: Capable of providing 100% of the cooling system load at 50° F dry bulb/45°F wet bulb



Economizers Standard 90.1

- Climate and size dependent (Table 6.5.1)
- There are LOTS of exceptions
- Can use air economizers
 1. 100% of design supply air
 2. Sequenced with mechanical cooling equipment
 3. High limit shutoff
 4. Dampers
- Can use water economizers
 1. 100% of expected system cooling load at 50°F DB, 45°F WB
 2. Maximum pressure drop limitation

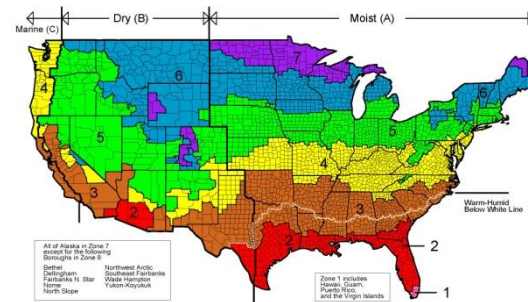
Economizer Exceptions

○ Exceptions:

- Cooling capacity - Table 6.5.1
- Systems with gas phase air cleaning per Standard 62
- Where >25% of the air must be humidified >35°Fdp
- Systems with condenser heat recovery per 6.5.6.2
- Residential systems <5X limits in Table 6.5.1
- Systems with a balance point ≤60°F
- Systems expected to operate < 20hrs/wk
- Systems serving zones with refrigerated casework
- Where cooling efficiency exceeds Table 6.3.2

Economizers (Table 6.5.1)

Climate zone	Cooling capacity for which an economizer is required
1a, 1b, 2a, 3a, 4a (Miami, St. Louis, Charlotte)	Economizer unnecessary
2b, 5a, 6a, 7, 8 (Yuma, Chicago, Edmonton)	$\geq 135,000$ Btu/h
3b, 3c, 4b, 4c, 5b, 5c, 6b (Denver, Lubbock, Vancouver)	$\geq 65,000$ Btu/h



March 24, 2003

Design Capacity – Air Economizers

- System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling

Variable Air Volume Fan Control IECC

Section 503.4.2

- Individual fans with motors $\geq 10\text{hp}$
 1. Driven by a mechanical or electrical variable speed drive **OR**
 2. Have controls or devices to result in fan motor demand $\leq 30\%$ of their design wattage at 50% of design airflow when static pressure set point = $1/3$ of the total design static pressure

Part Load Control IECC Section

503.4.3.4

System $\geq 300,000$ Btu/h shall have:

- Automatic Resets for Supply Water Temperature by 25% of Design Supply-to-Return Temperature Differences **or**
- Reduce System Pump Flow by 50% of Design Flow Using
 1. Multiple Staged Pumps
 2. Adjustable Speed Drives
 3. Control Valves with Modulate or Step Down Capabilities

Economizer Exceptions Standard 90.1

○ Exceptions:

- Cooling capacity - Table 6.5.1
- Systems with gas phase air cleaning per Standard 62
- Where >25% of the air must be humidified >35°Fdp
- Systems with condenser heat recovery per 6.5.6.2
- Residential systems <5X limits in Table 6.5.1
- Systems with a balance point ≤60°F
- Systems expected to operate < 20hrs/wk
- Systems serving zones with refrigerated casework
- Where cooling efficiency exceeds Table 6.3.2

Design Capacity – Air Economizers Standard 90.1

- System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling

Control Signal Standard 90.1

- Dampers capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature
- Exception: Systems controlled from space temperature (such as single-zone systems)

Standard 90.1 High Limit Shutoff

- Automatically reduce outdoor air intake to minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage
- Control types for specific climates from Table 6.5.1.1.3A
- Settings from Table 6.5.1.1.3B

Dampers Standard 90.1

- Return air and outdoor air dampers to meet the damper leakage specified in 6.4.3.4.4

Relief of Excess Outside Air Standard 90.1

- Means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building
- Outlet located to avoid recirculation into the building

Design Capacity – Water Economizers

- System capable of cooling supply air by indirect evaporation and providing up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below
- Exception: You can also meet this requirement if your design can meet 100% of expected cooling load at 45°F dry bulb/40°F wet bulb

Integrated Economizer Control IECC

- Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required
- Some exceptions to this

Economizer Heating System Impact IECC

- Designed so economizer operation doesn't increase the building heating energy use during normal operation
- Exception: Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature



Zone Controls – Exceptions Standard 90.1

- Zones for which volume of air that is reheated, recooled, or mixed is no greater than the larger of the following
 1. Volume of outside air to meet 6.2 of Standard 90.1 62 for the zone
 2. 0.4 cfm/ft^2 of zone conditioned floor area
 3. 30% of zone design peak supply
 4. 300 cfm for zones whose peak flow rate totals no more than 10% of the total fan system flow rate
 5. Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage
- Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that the variable air volume systems are impractical

Standard 90.1 Hydronic System Controls

- Limit heating and cooling of fluids previously heated or cooled mechanically per 6.5.2.2.1 through 6.5.2.2.3

Two-Pipe Changeover System Standard 90.1

- Common distribution system acceptable if
 1. Deadband from one mode to another is $\geq 15^{\circ}\text{F}$ outside air temperature
 2. Controls to allow operation of ≥ 4 hours before changing over
 3. Reset controls so heating and cooling supply temperatures at changeover point no more than 30°F apart

Hydronic (Water Loop) Heat Pump Systems IECC

- Controls to provide heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by central devices
- Cooling tower bypass or cooling tower isolation dampers
- A two-position valve at each hydronic heat pump for hydronic systems having a total pump system power > 10 hp
- Exception
 1. If system loop temperature optimization controller is used, deadband < 20°F is allowed

Hydronic System Design and Control Standard 90.1

- HVAC hydronic systems with total pump system power > 10 hp shall meet 6.5.4.1 – 6.5.4.4
 1. Hydronic Variable Flow Systems
 2. Pump Isolation
 3. Chilled and Hot Water Temperature Reset
 4. Hydronic (water-loop) Heat Pump Systems

Air System Design and Control Standard 90.1

- HVAC systems with total fan system power > 5 hp to meet 6.5.3.1 through 6.5.3.2
 1. Fan Power Limitation
 2. VAV Fan Control
 - Part Load Fan Power Limitation
 - Static Pressure Sensor location
 - Set Point Reset

Fan Power Limitation Standard 90.1

- Table 6.5.3.1
- Allowable fan system power may be adjusted if
 1. Air systems require air treatment or filtering systems with pressure drops > 1 in. w.c. when filters are clean, or heat recovery coils or devices, or direct evaporative humidifiers/coolers, or other devices to serve process loads in the airstream
 2. design room temperature – supply air temp at cooling design condition = $> 20^{\circ}\text{F}$, allowable fan system power may be adjusted
- Exceptions

Motor Nameplate Horsepower Standard 90.1

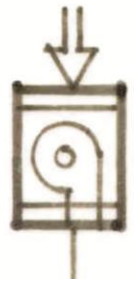
- Selected fan motor to be no larger than first available motor size greater than bhp
- Fan bhp on design documents
- Exceptions
 1. Fans < 6 bhp, where first available motor larger than bhp has nameplate rating within 50% of bhp, next larger nameplate motor size may be selected
 2. Fans ≥ 6 bhp, where first available motor larger than bhp has nameplate rating within 30% of bhp, next larger nameplate motor size may be selected

Part-Load Fan Power Limitation Standard 90.1

- Individual VAV fans with motors ≥ 10 hp

Must have either:

- Variable Speed Drive
- Vane axial fan with variable-pitch fan blades
- Other controls and devices to result in fan motor demand $\leq 30\%$ of design wattage at 50% of design air volume when static pressure set point = $1/3$ of total design static pressure, based on manufacturer's certified fan data



Static Pressure Sensor Location Standard 90.1

- Placed so controller set point is $\leq 1/3$ the total design fan static pressure--
 - Except for digital control systems with zone reset capabilities where it may be at the fan discharge
- Install multiple sensors in each major branch if sensor would be located downstream of a major duct split

Set Point Reset Standard 90.1

- For systems with direct digital control of individual zone boxes reporting to the central control panel, static pressure set point reset based on zone requiring the most pressure

Hydronic Variable Flow Standard 90.1

- HVAC pumping systems to include control valves
 1. Designed to modulate or step open and close as a function of load
 2. Designed for variable fluid flow
 3. Capable of reducing flow rates to $\leq 50\%$ of design flow rate
- Individual pumps serving variable flow systems with a pump head > 100 ft and motor > 50 hp
 1. Have controls and/or devices resulting in pump motor demand $\leq 30\%$ of design wattage at 50% of design water flow

Standard 90.1 Hydronic Variable Flow - Exceptions

- Systems where
 1. Minimum flow is $<$ minimum flow required by equipment manufacturer for proper operation of equipment served by the system
 2. Total pump system power \leq 75 hp
- Systems that include \leq 3 control valves

Pump Isolation Standard 90.1

- If chilled water plant has more than one chiller or boiler plant has more than one boiler
 1. Provide for flow reduction when chiller or boiler is shut down

Exhaust Air Energy Recovery

- Incorporate exhaust air energy recovery in systems with
 1. $\geq 70\%$ outside air and ≥ 5000 cfm total
 2. 50% energy recovery effectiveness



Standard 90.1 Exhaust Air Energy Recovery Exceptions

- Lab systems meeting 6.5.7.2
- Systems serving uncooled spaces that are heated to $< 60^{\circ}\text{F}$
- Systems exhausting toxic, flammable, paint or corrosive fumes or dust
- Commercial kitchen hoods used for collecting grease or smoke
- Where $> 60\%$ of outdoor heating energy is provided from site-recovered or site solar energy
- Heating systems in climate zones 1 through 3
- Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8
- Where largest exhaust source is $< 75\%$ of the design outdoor airflow
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil

Heat Recovery for Service Water Heating

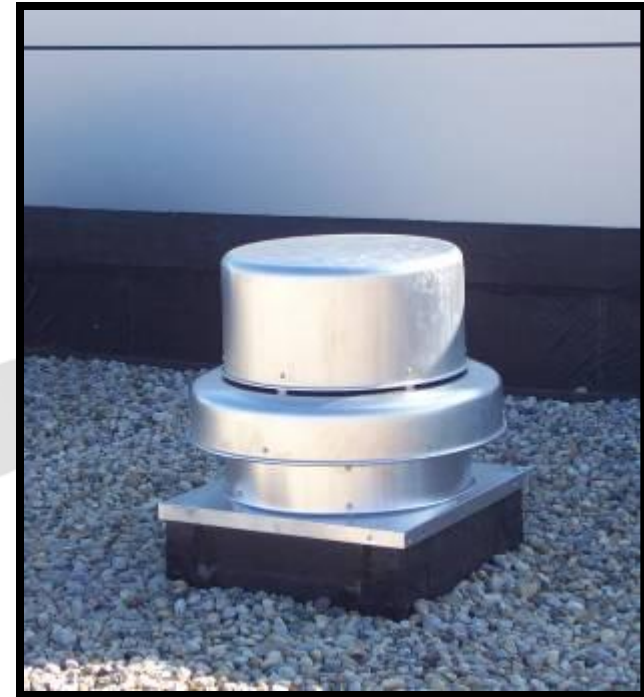
- Condenser recovery required if
 1. 24 hrs per day and
 2. Heat rejection $> 6,000,000$ Btu/h and
 3. SWH load $> 1,000,000$ Btu/h
- Exceptions

Kitchen Hoods (Exhaust) IECC

- Hoods > 5,000 cfm to be provided with makeup air sized for at least 50% of exhaust air volume that is a) unheated or heated to more than 60°F and b) uncooled or cooled without the use of mechanical cooling
- Exceptions
 1. Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems
 2. Certified grease extractor hoods that require a face velocity no greater than 60 fpm

Fume Hoods IECC

- Hood systems with a total exhaust rate $> 15,000$ cfm to have ONE of the following features
 1. Operation to $< 50\%$ design flow **OR**
 2. Direct make up at least 75% of exhaust rate at specified conditions **OR**
 3. Heat recovery for make-up air



Radiant Heating Systems IECC

- Required for unenclosed spaces except loading docks with air curtains
- “Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard”



Service Hot Water Systems

Placeholder
for
multimedia
slide.



SWH Compliance

Building System

Envelope

HVAC

SWH

Power

Lighting

Other

Mandatory Provisions

(required for most compliance options)

Compliance Options

Prescriptive Option

Trade Off Option

Energy Cost Budget

Simplified

Energy Code Compliance

Standard 90.1 Section 7 - Service Water Heating

- General (*Section 7.1*)
- Compliance Path(s) (*Section 7.2*)
- Mandatory Provisions (*Section 7.4*)
 1. Load calculations
 2. Equipment efficiency
 3. Service hot water piping insulation
 4. System controls
 5. Pools
 6. Heat traps
- Prescriptive Path (*Section 7.5*)
 1. Space heating and water heating
 2. Service water heating equipment
- Submittals (*Section 7.7*)



Equipment Efficiency - Standard 90.1

- Section 7.4.2 refers to Table 7.8 for equipment efficiencies
- Equipment not listed in Table 7.8 has no minimum performance requirements
- Exception: Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet standby loss requirements when
 - Tank surface is thermally insulated to R-12.5, and
 - A standing pilot light isn't installed, and
 - Gas- or oil-fired water heaters have a flue damper or fan-assisted combustion

Service Hot Water Piping Insulation Standard 90.1

- Table 6.8.3, Section 6
- Circulating water heater
 - 1. Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
 - 1. First 8 ft of outlet piping
 - 2. Inlet pipe between storage tank and heat trap
- Externally-heated pipes (heat trace or impedance heating)



Service Water Heating System Controls – Standard 90.1 and IECC

- Temperature Controls
- Temperature Maintenance Controls
- Outlet Temperature Controls
- Circulating Pump Controls



Heat Traps – IECC and Standard 90.1

- Noncirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)
 - Either a device specifically designed for this purpose or
 - Arrangement of tubing that forms a loop of 360° or piping that from the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable



Space Heating and Water Heating Standard 90.1

- Gas- or oil-fired space heating boiler system (complying with Section 6) is allowed to provide total space heating and water heating when ONE of the following conditions is met
 1. Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding
 - $(13.3 \times pmd + 400) / n$; where *pmd* is probable maximum demand in gal/h and *n* is the fraction of the year when outdoor daily mean temperature is $> 64.9^{\circ}\text{F}$
 2. Jurisdiction agrees use of a single heat source will consume less energy than separate units
 3. Energy input of the combined boiler and water heater system is $< 150,000 \text{ Btu/h}$
- Instructions for determining standby loss are included in this Section

Service Water Heating Equipment Standard 90.1

- Equipment used to provide the additional function of space heating as part of a combination (integrated) system shall satisfy all requirements for service water heating equipment

Temperature Controls Standard 90.1 and IECC

- To allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use
- Exception: if manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion

Temperature Maintenance Controls

Standard 90.1

- Automatic time switches or other controls
 - Set to switch off usage temperature maintenance system during extended periods when hot water is not required

IECC Mandatory Service Water Heating

- Service water-heating equipment performance efficiency (504.2)
- Table 504.2 Minimum Performance of Water-Heating Equipment
 1. Water Heater Types Covered
 2. Electric Storage
 3. Gas and Oil Storage
 4. Instantaneous Water Heaters – Gas and Oil
 5. Hot water boilers – gas and oil
 6. Pool heaters
 7. Unfired storage tanks
- Temperature Controls (504.3)
- Heat Traps (504.4)

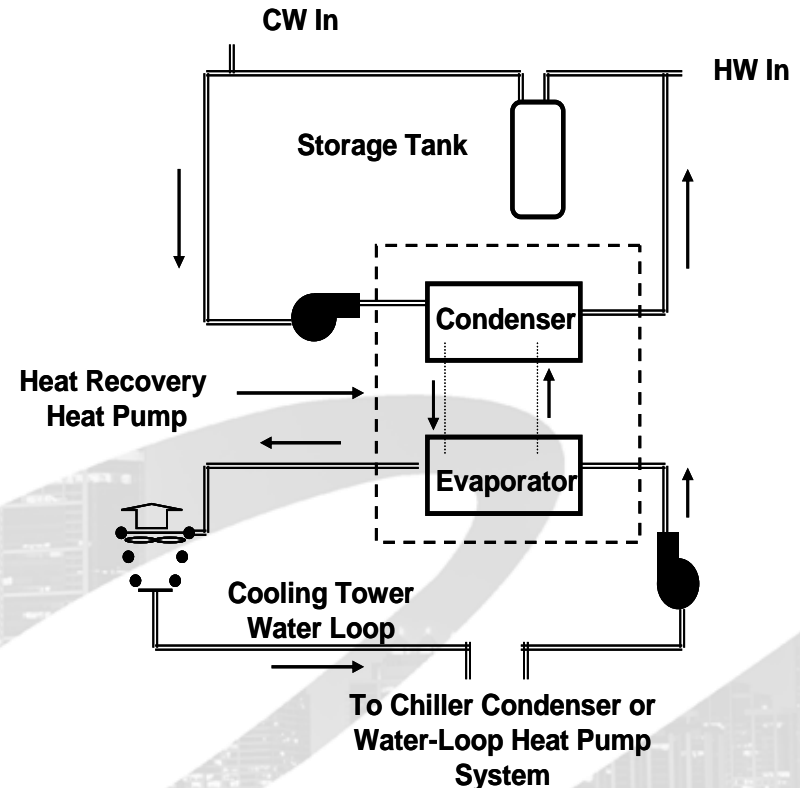
Heat Recovery for Service Hot Water Heating IECC Section 503.4.6

Most effective where water heater loads are large and well distributed throughout the day

- Typical applications: hotels, dorms, prisons, hospitals
- Condenser heat recovery required for heating/reheating of SWH provided:

1. Facility operates 24 hours/day
2. Total installed heat capacity of water-cooled systems >6,000,000 Btu/hr of heat rejection
3. Design SWH load >1,000,000 Btu/h

- Capacity to provide the smaller of
 - 60% of peak heat rejection load at design conditions OR
 - Preheating to raise peak to 85°F
- Exceptions



Outlet Temperature Controls Standard 90.1

- Controls provided
 1. To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F

Circulating Pump Controls Standard 90.1

- To limit operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

Pools – IECC and Standard 90.1

- Pool heaters to have readily accessible on-off switch
- Pool heaters fired by natural gas can NOT have continuously burning pilot lights
- Vapor retardant pool covers required (unless recovered or solar heat)
- Time switches required



Pool Requirements IECC Section 504.7

- Pool heaters (504.7.1)
 1. Readily accessible on-off switch
 2. Natural gas or LPG fired pool heaters will not have continuously burning pilot lights
- Time switches (504.7.2)
 1. Automatic controls required to operate pool heaters and pumps on a preset schedule
 2. Exceptions
 - Where public health standards require 24 hour operation
 - Where pumps are required to operate solar and waste heat recovery pool heating systems

Mechanical Equipment Efficiency Standard 90.1

- Tables 6.8.1A – 6.8.1G
- Tables 6.8.1H-6.8.1J used for water cooled centrifugal chillers that operate at non-standard rating conditions
- Combination HVAC and water heating systems to meet all requirements for appropriate space heating or cooling category
- Gas-fired and oil-fired forced air furnaces with input ratings $\geq 225,000$ Btu/h to have intermittent or interrupted ignition device and have either power venting or a flue damper
- All furnaces with input ratings $\geq 225,000$ Btu/h, including electric furnaces, not located in conditioned space, to have jacket losses $\leq 0.75\%$ of the input rating

Standard 90.1 Verification of Equipment Efficiencies

Equipment efficiency information from manufacturers verified as follows:

- EPACT equipment – to comply with DOE certification requirements
- If certification program exists for covered product and includes provisions for verification and challenge of equipment efficiency ratings, product listed in program OR
- If product not listed in program, ratings verified by an independent laboratory test report OR
- If no certification program exists, equipment efficiency ratings supported by data furnished by manufacturer OR
- Where components from different manufacturers are used, system designer specifies components whose combined efficiency meets Section .4.1
- Products in Table 6.8.1G shall have efficiency ratings supported by data furnished by manufacturer.

Labeling – Standard 90.1

- Mechanical equipment (6.4.1.5.1) – equipment not covered by NAECA shall carry a permanent label stating equipment complies with 90.1
- Packaged terminal air conditioners (6.4.1.5.2) – packaged terminal air conditioners and heat pumps with sleeve sizes < 16 in. high and 42 in. wide shall be factory labeled as follows:

Manufactured for replacement applications only, not to be installed in new construction projects

Hydronic Heat Pump Standard 90.1

- For heat pump loops with total pump system power > 10 hp: Two-position valves at each hydronic heat pump must be provided and interlocked to shut off water flow to the heat pump when the compressor is off
 - This basically converts the system into a variable flow system. As such, these systems must also comply with 6.3.4.1

Heat Rejection Equipment Standard 90.1

- Applies to heat rejection equipment used in comfort cooling systems such as
 1. Air-cooled condensers
 2. Open cooling towers
 3. Closed-circuit cooling towers
 4. Evaporative condensers
- Exceptions
 1. Heat rejection devices included as an integral part of equipment listed devices whose energy usage is included in Tables 6.8.1A-6.8.1D

Fan Speed Control Standard 90.1

- Each fan powered by a motor ≥ 7.5 hp
 1. Have capability to operate fan at $\leq 2/3$ full speed
 2. Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device
- Exceptions
 1. Condenser fans serving multiple refrigerant circuits or flooded condensers
 2. Installations located in climates zones 1 and 2
 3. 1/3 of the fans on a multiple fan application speed controlled

Submittals **IECC** and **Standard 90.1**

- Record drawings
- Operating and maintenance manuals
- System balancing
- System commissioning

Manuals IECC and Standard 90.1

- Operating and maintenance manuals to building owner within 90 days of system acceptance and include several items

System Balancing

- Systems shall be balanced in accordance with accepted engineering standards
- Written report for conditioned spaces $> 5000 \text{ ft}^2$
- Minimize throttling losses
- For fans with system power $> 1 \text{ hp}$: Adjust fan speed to meet design flow conditions

Standard 90.1 Hydronic System Balancing

- Proportionately balanced to minimize throttling losses
- Pump impeller trimmed or pump speed adjusted to meet design flow conditions
- Each system to have either the ability to measure differential pressure increase across the pump or have test ports at each side of the pump
- Exceptions
 1. Pumps with pump motors ≤ 10 hp
 2. When throttling results in $< 5\%$ of the nameplate hp draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed

System Commissioning

- Control elements are calibrated, adjusted, and in proper working condition
- > 50,000 ft² conditioned area
 1. Except warehouses and semiheated spaces
 2. Requires commissioning instructions

Standard 90.1 Minimum Equipment Efficiency Tables

- Equipment efficiency tables 6.8.1A to 6.8.1J
- Duct Insulation Tables 6.8.2A and 6.8.2B
- Pipe Insulation Table 6.8.3

Service Water Heating Submittals

- Authority having jurisdiction may require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this standard

IECC Snow Melt Controls for Residential and Commercial Projects

- Snow detector that will activate the system from the idle mode to the snow melt mode
- Require a slab temperature sensor that turns the system off when the surface temperature is above 50°F
- Temperature control that shuts the system down when the outdoor temperature is above 40°F

New for 2009



Controls - Freeze Protection and Snow/Ice IECC and Standard 90.1

- Automatic controls for
 1. Freeze protection systems
 - outside air temperatures $> 40^{\circ}\text{F}$ or when conditions of protected fluid will prevent freezing
 2. Snow- and ice-melting systems
 - pavement temperature $> 50^{\circ}\text{F}$ and no precipitation is falling and outdoor temperature $> 40^{\circ}\text{F}$

Standard 90.1 Commercial Compliance

Building System

Envelope

Lighting

Mechanical

HVAC

SWH

Mandatory Provisions

(required for most compliance options)

Compliance Options

Prescriptive Option

Trade Off Option

Total Building Performance

Energy Code Compliance

Standard 90.1 Power Compliance

Building System

Envelope

HVAC

SWH

Power

Lighting

Other

Mandatory Provisions

(required for most compliance options)

Compliance Options

Prescriptive Option

Trade Off Option

Energy Cost Budget

Simplified

Energy Code Compliance

Voltage Drop

- Two types of conductors

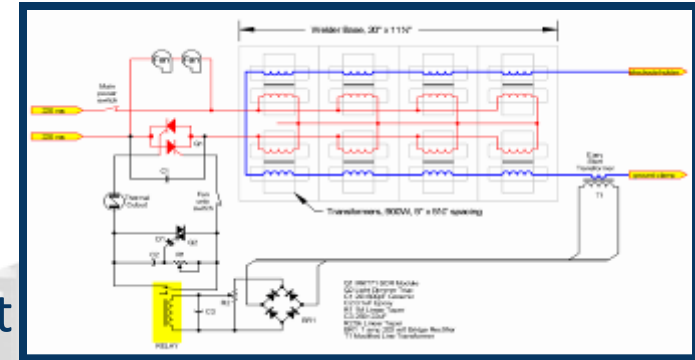
1. Feeder conductors

- Connect service equipment to the branch circuit breaker panels
- 2% maximum voltage drop allowed at design load

2. Branch circuit conductors

- Run from the final circuit breaker to the outlet or load
- 3% maximum voltage drop allowed at design load

3. These are more stringent than non-enforceable requirements in the National Electric Code (NEC)



Standard 90.1 Other Compliance Methods

Building System

Envelope

HVAC

SWH

Power

Lighting

Other

Mandatory Provisions
(required for most compliance options)

Compliance Options

Prescriptive Option

Trade Off Option

Energy Cost Budget

Simplified

Energy Code Compliance

Section 11 - Energy Cost Budget Method

- The ultimate trade-off method allowing you to trade-off across building systems through the use of annual, hourly simulation tools and a baseline building
- The only real way to deal with unique designs, renewables, high-efficiency equipment, etc.
- The basis of the energy portion of the LEED rating
- Limits allowable energy costs of the design to those of a building meeting the Standard
- Buildings must still meet all mandatory requirements (Section X.4)



Section 11 - Energy Cost Budget Method

- Tradeoff limited to building permit
- You have to have an approved building envelope design prior to ECB submittal
- You must meet all the X.4 sections AND the design energy cost cannot exceed the energy cost budget AND the energy efficiency level of components must meet or exceed the levels used to calculate the design energy cost
- You must document all this in great detail

Section 11 - Energy Cost Budget Method

- Use a good and approved simulation program
- Use appropriate and approved climate data
- Use appropriate and approved purchased energy rates
- Use the same simulation program, climate data, and purchased energy rates for both the design energy cost and energy cost budget
- Get approval to deal with exceptional calculations that aren't covered in the simulation program

Section 11 - Energy Cost Budget Method

- Develop your proposed building design and budget building design in accordance with Table 11.3.1. This table “locks down” a number of building design parameters
- Choose your budget building HVAC system from Figure 11.3.2 and Table 11.3.2A

Section 11 - Energy Cost Budget Method

- If you are attempting to show that your building goes “above code” (say, for instance, for LEED energy points) as opposed to simply using ECB as a very flexible and complex code compliance tradeoff option;

be sure to see Informative Appendix G, which contains many of the same elements as Section 11, but with modifications to accommodate the needs of “above code” programs

Standard 90.1 Section 12 - Normative References

- Normative (read “mandatory”) reference documents
- Includes test methods, rating procedures, and other standards

Standard 90.1 Rated R-Value of Insulation and Assembly

U-Factor, C-Factor, and F-Factor Determinations

- Includes pre-calculated U-factors, C-factors, and F-factors
 1. Above-grade walls
 2. Below-grade walls
 3. Floors
 4. Slab-on-grade floors
 5. Opaque doors
 6. Fenestration

Standard 90.1 Methodology for Building Envelope Trade-Off Option in Subsection 5.6

- The details of how the envelope trade-off option referenced in Section 5.6 is implemented
- This methodology is implemented in the ENVSTD software distributed with the 90.1 Users Manual

Standard 90.1 Climate Data

- Climatic data for a number of US, Canadian, and international locations
 1. HDD65 and CDD50
 2. Heating and cooling design temperatures
 3. “number of hours between 8 am and 4 pm with Tdb between 55 and 69”
- Used exclusively for HVAC calculations

Standard 90.1 Addenda Description Information

- Information on addenda to Standard 90.1-2004 (the predecessor to Standard 90.1-2007)
- 44 addenda to Standard 90.1-2004 issued
- Standard 90.1-2004 plus these addenda forms the basis of Standard 90.1-2007

COMcheck™

Desktop Software Tools



Windows

or

Mac versions

Free!

Web-Based Tools



Info You'll Need

Basic information about the builder and project

Area take-offs for exterior walls, fenestration, roof/ceiling,
basement walls, floors, etc.

Insulation R-values, fenestration
U-factors, etc.

Lighting fixture details

Heating and cooling system details

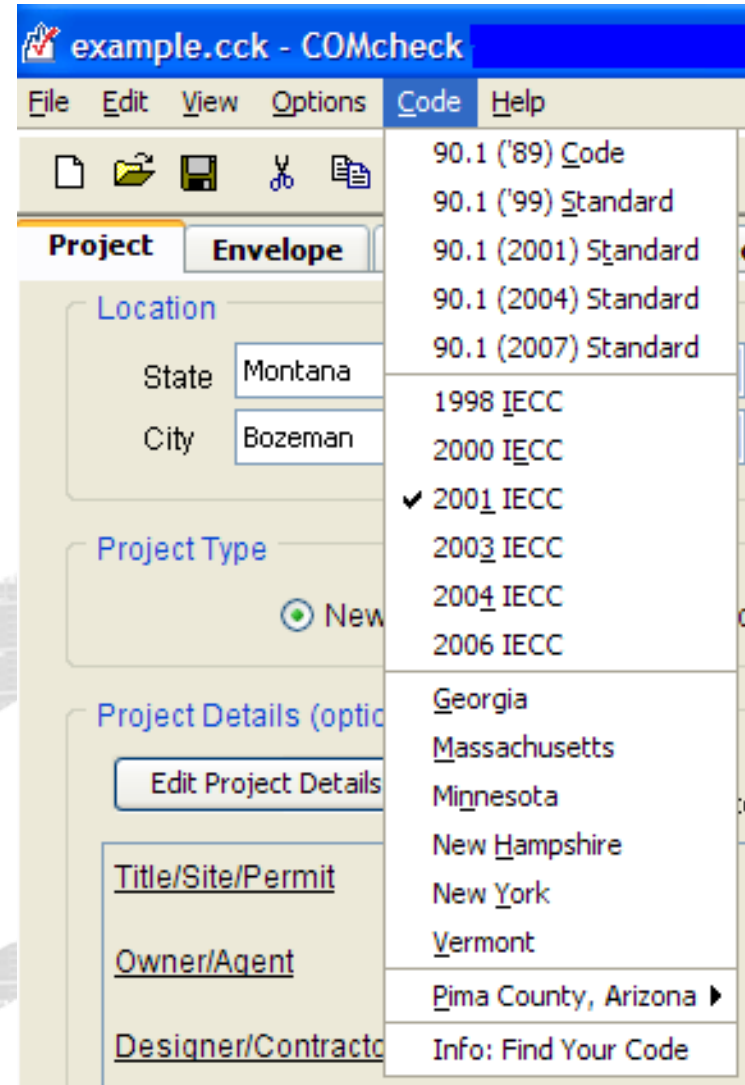
Service water heating details

Main Steps

- Select the Appropriate Code
- Enter Project Information
- Enter Building Components
- Enter Interior/Exterior Lighting
- Enter Mechanical Equipment
- View/Print the Compliance Report(s)
- Save the Data File and the Report

Appropriate Code

Energy code applicable
to
your state/ jurisdiction
(Code Menu)
Status of State Codes
Default
Preferences



Untitled.cck - COMcheck

File

Edit

View

Options

Code

Help

Project

Envelope

Interior Lighting

Exterior Lighting

Mechanical

Location

State

New York

City

Albany

Project Type

☒ New Construction

☐ Addition

Project Details (optional)

Edit Project Details...

This information will appear on the compliance certificate.

Title/Site/Permit

Owner/Agent

Designer/Contractor

Notes

Building Use

Add

Delete

Duplicate

	Building Area Type	Area	W/ft2
1	Click to select category.		

Total Area 0

Exterior Lighting Areas

Add

Delete

Duplicate

Help...

	Exterior Lighting Area	Quantity	Units
1	Click to select area type.		

Envelope

TBD

Interior Lighting

TBD

Exterior Lighting

TBD

Use the 'View' menu to display mandatory requirements.

Envelope Results



COMcheck Software Version 3.5.3

Envelope Compliance Certificate

2001 IECC

Report Date: 03/13/09

Data filename: C:\Program Files\Check\COMcheck\353\example.cck

Section 1: Project Information

Project Type: New Construction

Project Title :

Construction Site:

Owner/Agent:

Designer/Contractor:

Section 2: General Information

Building Location (for weather data): Bozeman, Montana

Climate Zone: 15

Heating Degree Days (base 65 degrees F): 7836

Cooling Degree Days (base 65 degrees F): 283

Vertical Glazing / Wall Area Pct.: 23%

Activity Type(s)	Floor Area
Office	4520
Convention, Conference or Meeting Center	420
Corridor, Restroom, Support Area	1400
Storage, Industrial and Commercial	2520
Industrial Work, < 20 ft Ceiling Height	2700
Lobby - Other	800

Section 3: Requirements Checklist

Envelope PASSES: Design 5% better than code.

Climate-Specific Requirements:

Component Name/Description	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Proposed U-Factor	Budget U-Factor
Roof 1: Non-Wood Joist/Rafter/Truss	6112	0.0	26.1	0.037	0.050
Skylight 1: Metal Frame, Double Pane, Tinted, SHGC 0.80	112	---	---	0.500	0.050
Exterior Wall 1: Solid Concrete or Masonry <= 8", Furring: Metal	6000	22.0	0.0	0.114	0.072
Door 1: Glass, Clear, SHGC 0.58	42	---	---	0.700	0.520
Window 1: Metal Frame, Double Pane with Low-E, Tinted, SHGC 0.63	1500	---	---	0.600	0.520
Window 2: Metal Frame, Double Pane, Clear, SHGC 0.72	56	---	---	0.700	0.520
Door 2: Overhead	288	---	---	0.140	0.118
Door 3: Solid	40	---	---	0.200	0.118
Interior Wall 2: Metal Frame, 16" o.c.	812	22.0	0.0	0.106	0.118
Basement Wall 1: Solid Concrete or Masonry <= 8", Furring: None, Wall Ht 12.5, Depth B.G. 7.0	2000	---	10.8	0.082	0.096
Floor 1: Slab-On-Grade/Unheated, Vertical 2 ft	160	---	10.8	---	---

6/23/08

Interior Lighting Results



COMcheck Software Version 3.6.0

Interior Lighting Compliance Certificate

2006 IECC

Section 1: Project Information

Project Type: **New Construction**

Project Title :

Construction Site:

Owner/Agent:

Designer/Contractor:

Section 2: General Information

Building Use Description by: Activity Type

Activity Type(s)	Floor Area
Office	4520
Convention Center	420
Warehouse	2520

Section 3: Requirements Checklist

Interior Lighting:

- ☐ 1. Total proposed watts must be less than or equal to total allowed watts.

Allowed Watts	Proposed Watts	Complies
7040	6136	YES

Controls, Switching, and Wiring:

- ☐ 2. Independent controls for each space (switch/occupancy sensor).

Exceptions:

Areas designated as security or emergency areas that must be continuously illuminated.
Lighting in stairways or corridors that are elements of the means of egress.

- ☐ 3. Master switch at entry to hotel/motel guest room.

- ☐ 4. Individual dwelling units separately metered.

- ☐ 5. Each space provided with a manual control to provide uniform light reduction by at least 50%.

Exceptions:

Only one luminaire in space;
An occupant-sensing device controls the area;
The area is a corridor, storeroom, restroom, public lobby or sleeping unit.
Areas that use less than 0.6 Watts/sq.ft.

- ☐ 6. Automatic lighting shutoff control in buildings larger than 5,000 sq.ft.

Exceptions:

Sleeping units, patient care areas; and spaces where automatic shutoff would endanger safety or security.

- ☐ 7. Photocell/astronomical time switch on exterior lights.

Exceptions:

Lighting intended for 24 hour use.

- ☐ 8. Tandem wired one-lamp and three-lamp ballasted luminaires (No single-lamp ballasts).

Exceptions:

Electronic high-frequency ballasts; Luminaires on emergency circuits or with no available pair.

Section 4: Compliance Statement



COMcheck Software Version 3.6.0

Interior Lighting Application Worksheet

2006 IECC

Section 1: Allowed Lighting Power Calculation

A Area Category	B Floor Area (ft ²)	C Allowed Watts / ft ²	D Allowed Watts (B x C)
Office	4520	1	4520
Convention Center	420	1.2	504
Warehouse	2520	0.8	2016
Total Allowed Watts =			7040

Section 2: Proposed Lighting Power Calculation

A Fixture ID : Description / Lamp / Wattage Per Lamp / Ballast	B Lamps/ Fixture	C # of Fixtures	D Fixture Watt.	E (C X D)
Office (4520 sq.ft.)				
Incandescent 1: G: Recessed wall washer / Incandescent 150W	1	2	150	300
Incandescent 2: H: Accent track lighting / Incandescent 50W	1	5	50	250
Compact Fluorescent 1: F: Down light, twin tube / Twin Tube 18W / Magnetic	2	31	46	1426
Convention Center (420 sq.ft.)				
T8 / T12 Fluorescent 5: E: 8 ft. Industrial, pendant mount / 96" T8 75W / Electronic	2	30	130	3900
Warehouse (2520 sq.ft.)				
T8 / T12 Fluorescent 3: C: 4 ft. Wall mount, wrap-around / 48" T8 32W / Electronic	2	4	65	260
Total Proposed Watts =			6136	

Section 3: Compliance Calculation

If the Total Allowed Watts minus the Total Proposed Watts is greater than or equal to zero, the building complies.

Total Allowed Watts =	7040
Total Proposed Watts =	6136
Project Compliance =	904

Interior Lighting PASSES: Design 13% better than code.

Exterior Lighting Results



COMcheck Software Version 3.5.3

Exterior Lighting Compliance Certificate

2006 IECC

Report Date: 03/12/09

Data filename: C:\Program Files\Check\COMcheck\353\example.cck

Section 1: Project Information

Project Type: **New Construction**

Project Title :

Construction Site:

Owner/Agent:

Designer/Contractor:

Section 2: Exterior Lighting Area/Surface Power Calculation

A Exterior Area/Surface	B Quantity	C Allowed Watts / Unit	D Tradable Wattage	E Allowed Watts (C x D)	F Proposed Watts
Drive-up window	2 window(s)	400	No	800	960
Main entry/exit	4 ft of door width	30	Yes	120	84
Parking area(s)	15000 ft2	0.15	Yes	2250	2200
Walkway < 10 feet wide	100 ft of walkway length	1	Yes	100	99
Total Tradable Watts* =				2470	2383
Total Allowed Watts =				3270	
Total Allowed Supplemental Watts** =				164	

* Wattage tradeoffs are only allowed between tradable areas/surfaces.

** A supplemental allowance equal to 5% of total allowed wattage may be applied toward compliance of both non-tradable and tradable areas/surfaces.

Section 3: Exterior Lighting Fixture Schedule

A Fixture ID : Description / Lamp / Wattage Per Lamp / Ballast	B Lamps/ Fixture	C # of Fixtures	D Fixture Watt.	E (C X D)
Drive-up window (2 window(s)): Non-tradable Wattage				
HID 1: Metal Halide 100W / Magnetic	1	8	120	960
Main entry/exit (4 ft of door width): Tradable Wattage				
Compact Fluorescent 1: Spiral 42W / Electronic	1	2	42	84
Parking area(s) (15000 ft2): Tradable Wattage				
HID 2: Metal Halide 100W / Magnetic	1	5	440	2200
Walkway < 10 feet wide (100 ft of walkway length): Tradable Wattage				
HID 3: Metal Halide 32W / Electronic	1	3	33	99
Total Tradable Proposed Watts =				2383

Section 4: Requirements Checklist

Lighting Wattage:

- ☐ 1. Within each non-tradable area/surface, total proposed watts must be less than or equal to total allowed watts. Across all tradable areas/surfaces, total proposed watts must be less than or equal to total allowed watts.

Compliance: Passes using supplemental allowance watts.

Controls, Switching, and Wiring:

Mechanical Report



COMcheck Software Version 3.6.0

Mechanical Compliance Certificate

2006 IECC

Section 1: Project Information

Project Type: **New Construction**

Project Title :

Construction Site:

Owner/Agent:

Designer/Contractor:

Section 2: General Information

Building Location (for weather data): **Bozeman, Montana**

Climate Zone: **6b**

Heating Degree Days (base 65 degrees F): **7836**

Cooling Degree Days (base 50 degrees F): **1769**

Section 3: Mechanical Systems List

Quantity System Type & Description

- | | |
|---|---------------------------------------------------------------------------------------------------------------------------|
| 2 | RT-2 & RT-3 - Pkg. gas/elec.: RT-2 & RT-3 - Pkg. gas/elec. |
| 1 | CU-1 - Condensing unit: Cooling: Field-Assembled DX System, Capacity >=90 <135 kBtu/h, Air-Cooled Condenser / Single Zone |
| 1 | UH-1 - Gas unit heater: Heating: Unit Heater, Gas |
| 1 | F-1 - Gas furnace: Heating: Central Furnace, Gas / Single Zone |

Section 4: Requirements Checklist

Requirements Specific To: RT-2 & RT-3 - Pkg. gas/elec. :

- ☐ 1. Newly purchased heating equipment meets the heating efficiency requirements
- ☐ 2. Specified equipment consists of field-assembled components - efficiency documentation provided
- ☐ 3. Cooling system provides a means to relieve excess outdoor air during economizer operation.
- ☐ 4. Integrated air economizer required

Requirements Specific To: CU-1 - Condensing unit :

- ☐ 1. Specified equipment consists of field-assembled components - efficiency documentation provided
- ☐ 2. Cooling system provides a means to relieve excess outdoor air during economizer operation.
- ☐ 3. Integrated air economizer required

Requirements Specific To: UH-1 - Gas unit heater :

- ☐ 1. Equipment minimum efficiency: Unit Heater (Gas): 80% Ec

Requirements Specific To: F-1 - Gas furnace :

- ☐ 1. Newly purchased heating equipment meets the heating efficiency requirements

Generic Requirements: Must be met by all systems to which the requirement is applicable:



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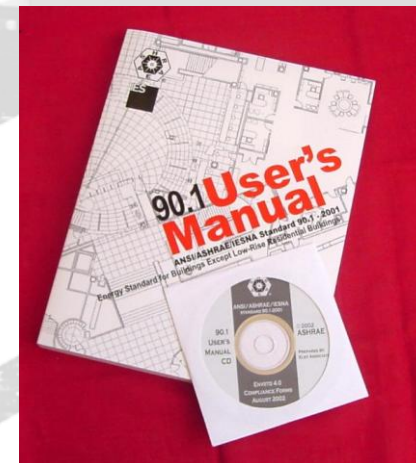
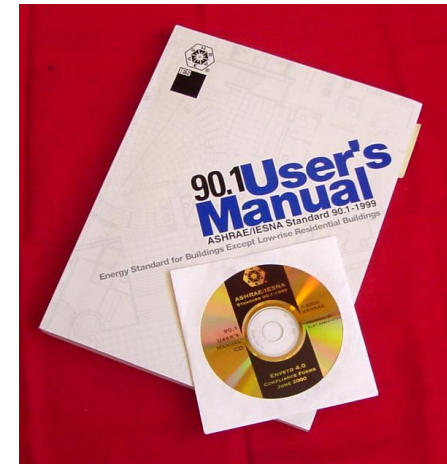
[SHGC Code Compliance](#)

[Article #107: How does the energy code define an addition?](#)

[Article #106: How Do I Enter Non-Uniformly Insulated Basement Walls in REScheck?](#)

Interpretations for Standard 90.1

- 90.1 Users Manuals
 1. Provides much of the background
- Formal Interpretations
 1. Formal written interpretations take time
- Informal Interpretations
 1. Quick, informal answers to questions
- Manager of Standards (404) 636-8400



Conclusions

- National, State and Local governments are paying attention to energy codes.
- Increased federal funding toward energy codes.
- Governor assurance letters included energy code provision.
- Energy codes are a critical part of building design.